BRASS PIPE & PIPING

A proof of the everlasting qualities of brass is a beam-head taken from a sunken Roman ship in Lake Nemi, after having been immersed in water for 2000 years, and now on display as a specimen of bronze-preservation in the Roman National Museum. The figure is the head of a lioness, with moveable ring behind the "locked" incisors.

Brass Pipe and Piping

When and how it should be used

Bridgeport BRASS CO TRADE MARK

Bulletin No. 15

Bridgeport Brass Company
Bridgeport Connecticut

Figure 1. The pipe mill of the Bridgeport Brass Company is completely equipped with special machinery for the production of seamless brass pipe of definite and uniform specifications.

Foreword

THE reason for brass pipe is corrosion. If it were not for corrosion there would be no brass pipe. Iron and steel, though intrinsically cheaper than brass, are more expensive in installations where the corrosion factor plays an important part.

Brass pipe will invariably be chosen for hot and cold water service installations if the two following factors are properly considered.

a. Money value of the service that will be rendered during the life of the pipe.

b. Design of the installations to provide the required facilities with the least amount of material.

While our desire, admittedly, is to encourage the use of brass pipe, it is likewise our purpose to present useful information that will assist architects, engineers, builders, plumbers, owners and others in obtaining the maximum value for a given expenditure for brass pipe under existing conditions; therefore, any criticisms or suggestions for improvement will be appreciatively considered.

BRIDGEPORT BRASS COMPANY

Brass vs Iron and Steel for Hot Water Service

All Pipes Corrode

All pipe, whether steel, wrought iron, cast iron or brass will fail some day by corrosion. It is simply a matter of time, and when permanent construction is involved the best pipe is the one that will last the longest. Difference in first cost will not justify any other conclusion.

Steel, wrought iron, cast iron and brass pipe each has its proper field of usefulness. No experienced builder will seriously question the following:

- Brass for salt water piping, for hot water supply piping, and for cold water supply piping at least where the lines are concealed.
- Steel or wrought iron for heating systems.
- Cast iron for soil pipes, vents and underground service.

Brass for Minimum Corrosion

Leading iron and steel pipe manufacturers admit the superiority of brass in water supply systems where corrosion is encountered. Exhaustive studies furnish all the data necessary to prove the marked susceptibility of both iron and steel to destruction by corrosion, and the comparative immunity of brass. The evidence against the use of iron in water supply systems is amply supported by published data.

Iron and Steel in Hot Water Service

Galvanizing the inner surface of iron and steel pipe is employed to prolong its life, and has been found to possess some advantages. Sufficiently satisfactory results, however, are not assured to warrant the expectation of materially increased life in service. Such galvanizing prevents rusting when the pipe is new and during the period between its manufacture and its installation.

Some years ago an investigation was made in St. Louis by Professor Earle B. Phelps, of the Massachusetts Institute of Technology, which showed that corrosion troubles in St. Louis were generally confined to galvanized installations. These pipes, although they had been in service only a few years, were often completely choked with a "yellowish white substance," which adhered so firmly to the surface that it brought away with it flakes of the zinc coating when it was removed. Brass pipe installations revealed no deposits and no signs of corrosion. The interior

surface of the specimens examined was apparently as good as new.

One reason why galvanizing sometimes increases the susceptibility of iron pipe to corrosion is the fact that water, from which organic matter has been removed, and which has been chemically treated, often dissolves zinc more readily. Once the zinc coating is perforated, corrosion proceeds with greater rapidity because of concentrated action on small areas. Galvanized pipe is also apt to give trouble where a considerable amount of carbon dioxide is contained in the water.

TABLE I

GRAND AVERAGE OF FOUR CORROSION TESTS ON IRON AND STEEL PIPE*

	Steel Pipe (13 Samples)		Wrought Iron (7 Samples)	
	In.	Per Cent of Wall	In.	Per Cent of Wall
Depth of deepest pit	0.059	38	0.077	49½
Depth of first five deepest pits......	0.052	33½	0.069	44½
Depth of second five deepest pits......	0.042	27	0.057	37
Depth of three above classes...........	0.051	35	0.067	43

NOTE: The average thickness of wall of 2-inch standard pipe is 0.155 inches, the average depth of thread is 0.07 inches. Pipes which pit through at the thread have an average pit depth of 0.085 inches.

* National Bulletin No. 2D, 5th Edition, September, 1920, page 19, National Tube Company.

Hydrogen sulphide, sometimes present in artesian water, dissolves zinc, producing zinc sulphide, and when constantly present, often causes sickness — the symptoms of which are cramps, fainting spells and nausea.

In New York City, to compare wrought iron pipe with steel pipe, tests were made in lines supplying public shower baths. The period of observation varied from two years and five months to two years and nine and one-half months. The average results from four separate tests published by one of the pipe manufacturers are entered in Table 1.

Another test reported in the same publication covers samples of wrought iron, black steel, copper-alloy steel, galvanized steel and galvanized copper-alloy steel.

These tests were made in a hot water line with the various samples connected in series. The period was eleven months, although for about three and one-half months during the summer season almost no water was

Figure 2. Piece of galvanized steel pipe used for 1½ years for hot water supply to a garage. It was enclosed in concrete; thus encased it was used until completely destroyed.

taken through the pipes. At the end of the tests the pipes were practically filled with rust. This deposit was removed and the inside surface brushed with a wire brush. The corrosion was then measured by means of a depth gage. The average depths of the first 40 pits were as given in Table II.

TABLE II

CORROSION TESTS *

	In.	Per Cent
Wrought Iron	0.0674	43.5
Steel	0.0544	35.1
Copper-Alloy Steel	0.0639	41.2
Galvanized Steel	0.0547	35.3
Galvanized Copper-Alloy Steel	0.0938	60.5

* National Bulletin No. 2D, 5th Edition, September 1920, page 20, National Tube Company.

Brass vs. Iron and Steel in Hot Water Service

One of the manufacturers of iron pipe made a comprehensive investigation some years ago of piping installations in Pittsburgh.* The published reports of the observations indicate that the life of wrought iron pipe under these particular conditions is approximately twice that of steel pipe. Among the buildings examined, there were 34 equipped with brass pipe. These installations ranged in age from six to eighteen years and yet none had failed. The fact that not one of the brass pipe installations had failed makes it impossible to give the brass full credit because no one knows how long these brass installations may continue in service without failure. Of the 28 steel installations which range in age from five to eleven years, 85 per cent had failed, and of the 67 wrought iron installations ranging in age from six to nineteen years, 92 per cent had failed. For easy comparison Table III was compiled from the detailed data tabulated in the original report.

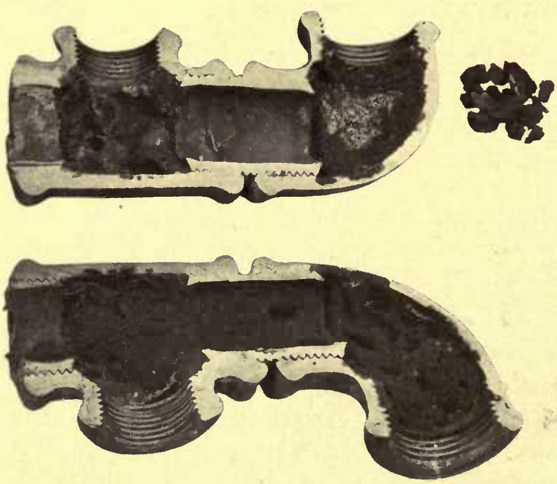


Figure 3. Galvanized iron fittings with brass nipples. Brass untouched, iron fittings filled with rust and at one point completely perforated.

* Byers' Pipe Bulletin No. 30, 3d Edition, October 1913. A. M. Byers Company.

TABLE III

RESULTS IN ACTUAL PIPING INSTALLATIONS IN THE PITTSBURGH DISTRICT

	Brass	Steel	Wrought Iron
Number of installations	34	28	67
Number of failures	None	24	62
Number of renewals	None	19	49
Maximum age of time of inspection, years	18	11	18*
Average age at time of inspection, years	11⅓	7⅛	14
Average time to first replacement, years	**	5⅔	10½
Minimum time to first replacement, years	**	2	6

* Repaired.

** No replacements.

Rust Accumulation in Iron and Steel Pipes

Corrosion in iron or steel pipe produces "rust." Sometimes this rust clings to the surface of the pipe with great tenacity; at other times it is loosened by the flow of the water and carried along. Iron converted into rust occupies 10 times its volume as a metal, therefore tremendous quantities of rust are produced as corrosion proceeds.

Rusty water stains porcelain fixtures and textile fabrics. A leak in an iron or steel pipe will inevitably carry rusty water, which will stain floors, ceilings, walls or whatever articles of furniture or furnishings it may encounter.

When rust clings to the surface it does not take long to plug the pipe. When it is considered that 1/27th of an inch corroded from the interior surface of a 1½-inch pipe will fill it solid with rust, it is evident that only a short time is required to choke the line and make it useless, unless the rust is flushed away by the action of the water. The smaller the pipe the more serious this action: in a 1-inch pipe it requires only 1/40th of an inch removed by corrosion to fill it with rust.

Figure 4. Galvanized iron fitting clogged with rust from the hot water piping.

The plugging of pipes usually occurs more rapidly than the time required to produce the rust in any one section, because at restricted points, as in elbows or at the bottom of a riser, rust from considerable lengths of pipe will naturally collect. Plugged pipes especially in hot water service are common occurrences. An actual example is shown in Figure 4.

A distinct advantage of brass pipe is the absence of any process of corrosion to discolor the water and plug the pipes. Engineers employ smaller sizes of brass pipe for a given service than of either iron or steel, because the full carrying capacity of the brass can be counted upon throughout its life.

Lead Pipe

Lead has been used for the manufacture of pipe for hundreds of years. In some parts of Europe large water mains of lead are still in existence. In cold water service it is fairly satisfactory, but in hot water service it is apt to give trouble. Lead pipe should not be used in systems supplying drinking water because of the danger of lead poisoning. Massachusetts State Board of Health condemns water which contains 0.1 grain of lead per gallon. The serious thing about this poisoning is its cumulative character, for no matter how small the dose, a definite effect is produced, and each additional dose adds to that effect until serious illness and possibly death results.

Lead Lined Pipe

A certain amount of steel pipe lined with lead has been placed on the market but has never come into extensive use because of the following factors:

1. Difficulty of producing a pipe free from faults in the lining. A slight burr on the pipe projecting through the lead lining will set up electrolytic action and cause failure.
2. Difficulty of making joints without exposing the steel behind the lead, and setting up serious electrolytic corrosion.
3. Cost approaching that of brass with actual life not materially better than steel.

Installations of this kind have been known to fail completely in about five years, probably due to intense electrolytic action at points where the lead lining was damaged from one cause or another.

Bridgeport Plumrite Brass Pipe

The Bridgeport Brass Company denotes as "Bridgeport Plumrite" that brass mixture which is best suited to the manufacture of brass pipe for fresh water service, and for carrying certain liquids used in chemical processes. The action of hot salt water and certain other liquids is particularly severe and for such purposes brass of special composition is recommended.*

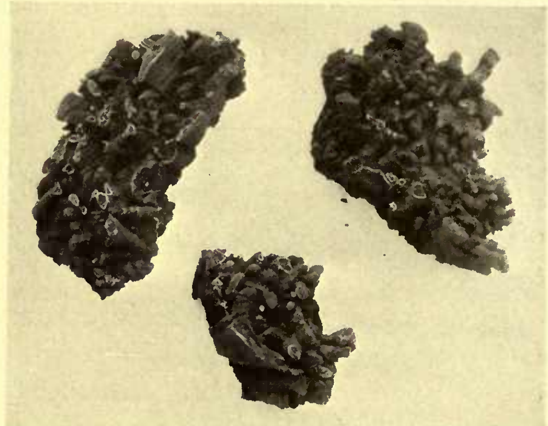


Figure 5. Pieces of rust (full size) taken from the interior surface of a genuine wrought-iron pipe after seven years in hot water service.

This pipe has been manufactured by the Bridgeport Brass Company for more than forty years. In the early days some changes were made in composition, but for many years the only changes have been in the nature of refinements in the processes of manufacture for the purpose of increasing uniformity and maintaining the standard of quality.

Although Plumrite brass pipe has been employed all these years we know of no instance of its removal because of corrosion. It is conservative to state that the life of this pipe is at least that of the building itself.

* The Bridgeport Brass Company's Research Department is equipped to study special problems, and is prepared to recommend the proper metal for each particular set of conditions which may be in any way extraordinary.

CORROSION

While there is no absolute unity of opinion on the theory of corrosion, perhaps a comparison with a simple battery will best serve to explain the generally accepted opinion that electrolytic action, due to a difference in potential between one part and another of the pipe, is the cause of corrosion.

A simple primary battery made by inserting a carbon and a zinc rod into a jar containing salt water will, when a voltmeter is connected with one side to the carbon rod and the other side to the zinc rod, indicate an electrical potential difference which is denoted as an electromotive force (e.m.f.). It will also be found that to cause a deflection in the right direction, the positive terminal of the voltmeter must be connected to the carbon rod, indicating the carbon to be the positive pole of the battery, and the zinc the negative pole.

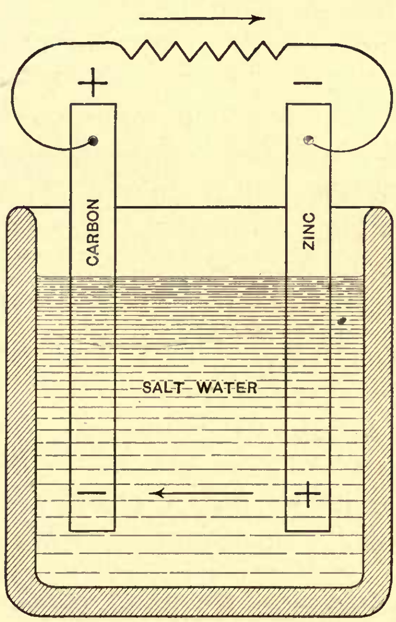


Figure 6. Simple electrolytic cell, demonstrating the various elements that enter into electrolytic corrosion. Anode (electropositive area) = Zinc; Cathode (electronegative area) = Carbon; electrolyte (water) = salt solution. These three elements are necessary for corrosion.

Referring to Figure 6, if a connection is made from the positive to the negative pole of the battery, electricity will flow in the circuit thus formed: that is, electricity will flow from the positive pole to the negative pole through the circuit, but inside of the battery it will flow from the zinc to the carbon, as shown by the arrow.

Where electricity leaves a metal and enters a liquid, as is here the case, the metal is dissolved and goes into solution, but where electricity leaves the solution and goes into a metal there is no dissolution of the metal.

The battery shown in Figure 6 illustrates electrolytic action. The zinc is the anode or the place from which the electricity flows into the solution. The carbon is the cathode or the place where the electricity leaves the solution. The salt solution is the electrolyte which carries the electricity from the anode to the cathode. In order to have electrolytic action or corrosion, it is necessary to have an anode, cathode and an electrolyte.

The anode is always the area of metal which is corroded. The electrolyte is the water carried by the pipe, and the cathode which completes the electrolytic system is either an impurity in the chemical composition of the metal, an ingredient in the alloy

of the metal, or an area that is physically different from the anode area.

The actual process of corrosion takes place in a series of energy transformations. It would serve no purpose to discuss these in detail in the present instance, but the fundamental principle perhaps can be stated to advantage. If it is assumed that an iron pipe containing water is allowed to stand, a certain amount of iron will be dissolved from the electro-positive areas. If oxygen is present the iron will be oxidized and form rust, which will be deposited on the electronegative area; sometimes this rust is of such a nature as to cling to the surface and gradually fill up the pipe—other times it is so loosely attached that the flow of the water carries it away.

Initial conditions may be such as to produce electrolytic action, and said action may so alter the conditions that it checks itself. This explains instances where corrosion is rapid for a time and then slows down to a much lower rate. Sometimes this result is accomplished by a chemical change on the surface of the pipe—other times it is caused by the concentration of hydrogen at the negative areas. The building up of this opposition is called *Polarization*. For example, in the case of a pipe filled with water but free from oxygen, electrolytic action results in dissolving iron by the water and releasing hydrogen which migrates to the negative areas of the pipe, causing polarization and thus stopping the corrosive action. Even pure water will dissolve iron and this action is entirely independent of the presence of air or oxygen. The quantity of iron dissolved depends upon the character of the water. Small amounts of acid greatly increase the quantity of iron which goes into solution.

If corrosion is to continue, oxygen must be supplied to take up the hydrogen and oxidize the iron out of the solution, by forming iron hydroxides so that it can absorb more. In heating systems, where no new water is introduced, the oxygen is soon used up, and the water dissolves all the iron it has oxygen to satisfy when corrosion practically ceases. Thus is explained the utility of iron and steel pipe in hot water heating and sprinkler systems.

In iron or steel service pipes carrying large quantities of water, oxygen is plentiful and corrosion proceeds rapidly. Heating the water increases the rate of corrosion, so that hot-water pipe usually lasts only one-third to one-fifth as long as the same pipe in cold water service.

To sum up, the conditions producing rapid corrosion of a given metal are:

1. Electro-negative substances.
2. Electrolyte.
3. Oxygen.

Electro-Negative Substances

Iron and steel are composite structures always containing impurities. They are never perfectly homogenous and never free from segregations, furnishing electro-negative areas to start corrosion.

Modern high-speed production methods in the iron and steel industry aggravate characteristics which aid corrosion. Brass, on the other hand, can be made of pure metal, thoroughly

mixed and cast without segregation, and it can be worked and annealed so as to leave no internal strains. This means that electro-negative areas can be uniformly distributed and that pitting is practically impossible. When properly made it is almost corrosion-proof as far as water is concerned.

Electrolyte

In service pipes the electrolyte is water. This water is never quite pure, so that its ability to dissolve iron may vary over a considerable range. Pure distilled water will dissolve iron and act as an electrolyte. Impurities simply increase the activity of water in the corrosion process.

Oxygen

The oxygen necessary for continued corrosion is supplied by the water. Therefore, the more water carried by the pipe the greater the corrosion. Furthermore, the activity of the oxygen is greatly increased by heat.

Corrosion of Brass

Someone has visualized corrosion by calling it nature's method of returning metals to the natural state in which they are found in the earth. Iron being found as an oxide, attempts at every opportunity to break away from the metallic state and return to the oxide state. Copper, which is the major constituent of brass, on the other hand is found in nature in a pure metallic state. Therefore, it has no tendency similar to iron to change its condition from the pure metal to an oxide. Zinc, on the other hand, which is the second principal constituent of brass, is not found in pure metallic form in nature. Therefore, when corrosion does take place it is most often the zinc which is transformed.

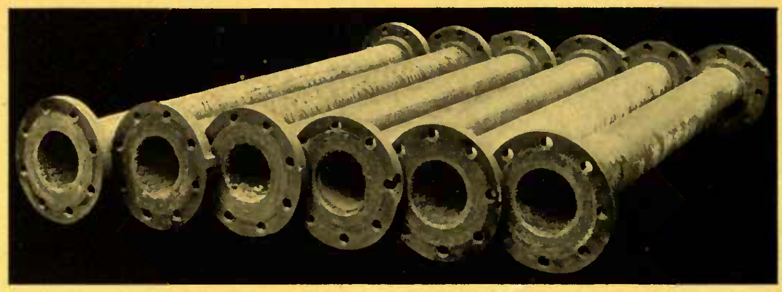
Electrolytes in Corrosion of Brass

Brass properly made will not dissolve in ordinary drinking water, and corrosion cannot take place unless metal goes into solution. Plumrite brass is made for pipes carrying ordinary fresh water, hot or cold, such as is used for drinking and bathing. Where salt water is concerned, a special mixture is used which contains a higher percentage of copper, and besides zinc, contains certain other ingredients. Water carrying ammonia, nitrates or nitrites, will corrode brass. Decaying vegetable matter produces nitrogen compounds. However, experience demonstrates that vent pipes which carry sewer gases in which there are fumes from decaying vegetable matter, can be made of brass pipe to advantage, because such gases produce a rapid and uniform corrosion which coats the pipe with a hard, dark-colored layer of material that effectively protects it from the nitrogen compounds.

Oxygen in the Corrosion of Brass

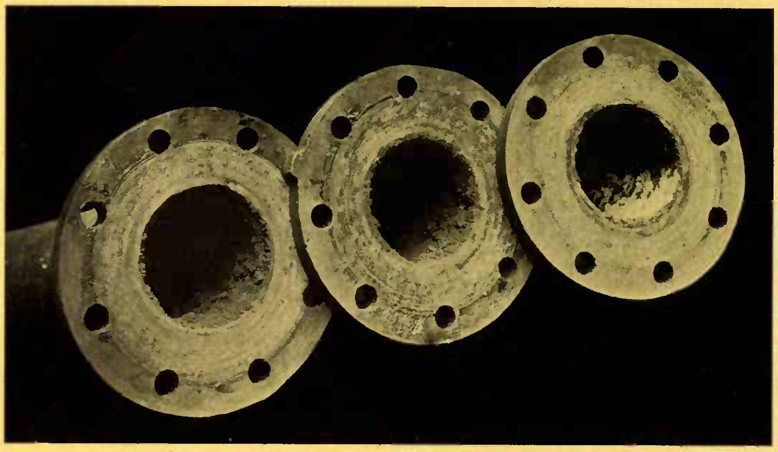
Since Plumrite Brass does not dissolve in ordinary fresh water, whether hot or cold, it is not affected by oxygen in the water. Oxygen in drinking water is healthful and palatable. Large water-works systems go to a considerable expense to aerate water, charging it with as much air as it will carry.

Figure 7. Pieces of pipe here shown were installed in a feed water line operating at 200° F. All the pipes except the brass and the lead lined have been in service for eight years, the latter have been in service seven years. It is interesting to note that the amount of corrosion is practically the same in steel and genuine wrought iron, whether used black or galvanized. All four specimens appear to be equally corroded.

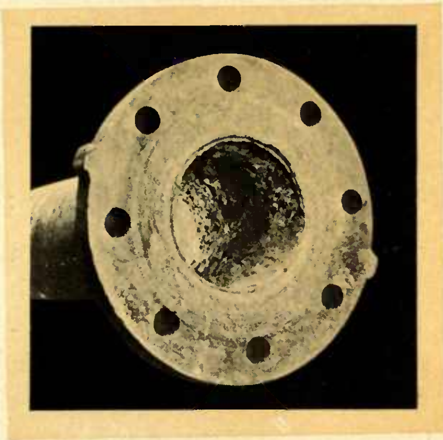


A — Sample lengths of pipe taken from this system. Beginning at the left the pipes are: Black wrought iron, black steel, iron dipped in lead, Plumrite brass, galvanized genuine wrought iron and galvanized steel.

B—Close view of three of the pipes showing the character of the corrosion. Beginning at the left they are: Black genuine wrought iron, black steel and iron dipped in lead. These specimens have not been scraped or disturbed in any way.

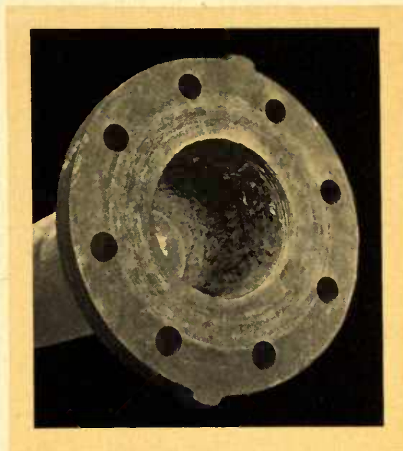


C — Close-up of three specimens showing the corroded surfaces undisturbed. Beginning at the left they are: Plumrite brass, galvanized genuine wrought iron and galvanized steel. There is absolutely no sign of corrosion in the Plumrite which is smooth and clean inside. All the other pipes are lined with large masses of rust. Both the iron and the steel pipe exhibit rust of similar character and quantity.



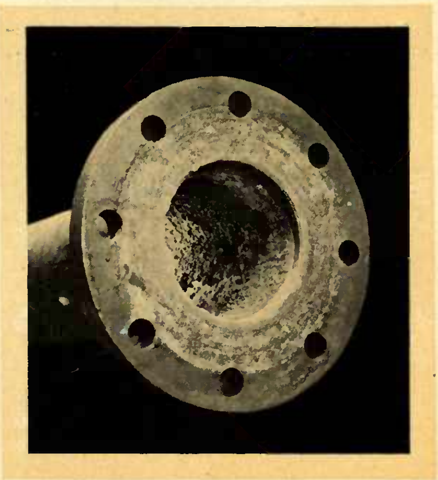
D

D—Black steel. The rust has been scraped away with a dull tool to determine the depth of the corrosion. The rust was very hard and if it had been scraped with a sharper instrument it would have revealed deeper pitting than is here shown. Careful examination will reveal that there is practically no pipe left at the threads.



E

E—Galvanized steel which has been scraped to reveal pitting. Wall of pipe at threads practically eaten through.



F

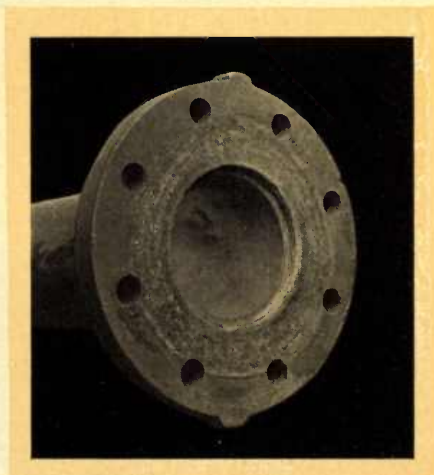
F—Genuine wrought iron which has been scraped to reveal pitting. Wall of the pipe is very nearly consumed at threads.

G

G—Galvanized genuine wrought iron which has been scraped to reveal pits. Corrosion is even worse than in the black metal and the wall of pipe is actually punctured at the threads.

H

H—Lead dipped iron pipe. The corroded lead is clearly visible as is also the corrosion of the iron under the lead lining. The rust was picked out from behind the lead with a sharp instrument revealing the cavities which extended practically through the wall of the iron at the threads.



I

I—Plumrite Brass Pipe. It will be noted that there is absolutely no sign of corrosion. The original wall thickness of the pipe is plainly visible at the end. The life of this pipe would certainly exceed that of the boiler to which it supplies feed water.

PROLONGING THE LIFE OF IRON AND STEEL PIPE

Corrosion of Iron and Steel

It was shown in the preceding chapter that electro-negative areas are largely responsible for corrosion, and since in the manufacture of iron and steel it is impossible to eliminate these, corrosion must be attacked by seeking to control the water in the pipe.

By removing the air or oxygen from water before it enters iron or steel pipe, corrosion can be reduced, prolonging the life of the pipe. At present there are two methods in use:

1. Deactivation A system through which the service water passes, exposed to large surfaces of iron for a sufficient time to give up its oxygen by corroding the iron before the oxygen has an opportunity to attack the pipe.

2. Deaeration A system designed to boil all the air out of the water at either

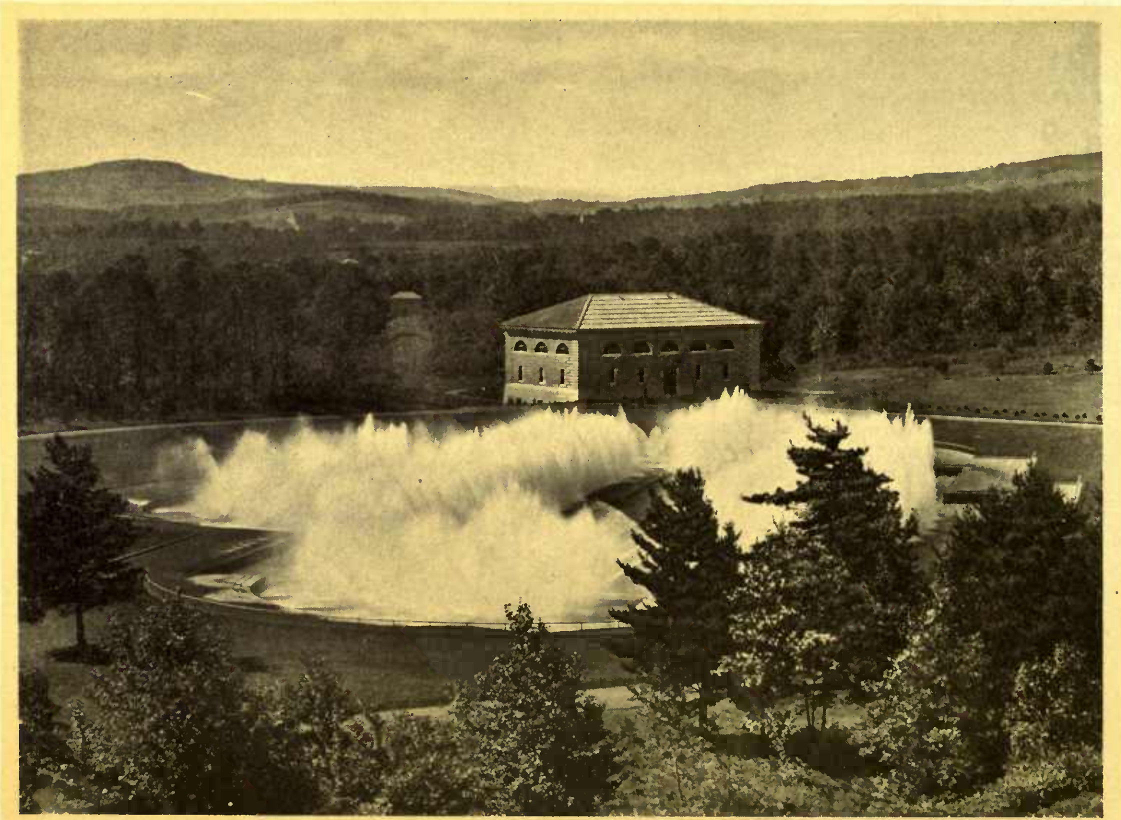


Figure 8. The water supplied to New York City is purified at the start by charging with air before being conducted underground ninety miles to the city.

atmospheric pressure or in a vacuum.

Both of these systems have served to prolong the life of iron and steel-pipe installations, and even though introducing another element, are in some cases preferable to repiping, which in our modern buildings represents a very great expense. These are, however, at best only a check, and unless the installation is extremely large, designed to take care of maximum requirements, they cannot perform satisfactorily when most needed.

New Construction

The installation of brass pipe in new construction precludes the ultimate need of considering a secondary installation for prolonging pipe life. Furthermore, the reduction or even elimination of air or oxygen in water does not wholly prevent corrosion of iron or steel service piping, since without the presence of these agencies water still has ability to dissolve a certain amount of iron. Also, no system of treating the water flowing through the pipe can possibly affect the outside corrosion, often an important factor in iron and steel piping, especially when exposed to a damp atmosphere.

Principles of Deactivation

In judging a deactivating plant it must be remembered that deactivation can only take place where water is left in contact with iron long enough to permit the process of corrosion to extract all the oxygen. Therefore, it is of first importance in selecting an outfit to be sure that the maximum demand for hot water can be supplied and still give time for the deactivation process to take place.

In most installations the rate of using hot water throughout the 24 hours varies enormously. Not only is this true of the 24-hour periods, but it is also true of the weekly periods. Therefore, a guarantee on the part of the company furnishing the deactivator should not be accepted on the basis of *average* flow, but rather on the basis of *maximum* flow.

The question of temperature must also be considered. For instance, for the purposes of comparison it may be stated, that with a given installation it required 24 hours at room temperature to deactivate the water. At 180° F. it required only half an hour, and at 212° it required only a few minutes. This characteristic adds one other obstacle to the successful operation of a deactivator, because when water is being drawn at the maximum rate, it usually drops in temperature. Consequently, the deactivation is enormously retarded at the very time when it should be increased.

It can be said in favor of the deactivator that most of iron that is rusted in the deactivator has saved a corresponding amount of rust from the piping system, but it cannot be claimed, and is not claimed, that a deactivator can be made of such proportions that it will eliminate all corrosion in the piping system of a modern building.

In addition to the difficulties resulting from large fluctuations in flow and temperature, deactivators also usually suffer from lack of proper circulation

in such a way that water passing through rapidly is apt to take a shorter course than water that passes through slowly. In many cases proper circulation cannot be employed, because of the difficulties of settling out the rust which under present methods is collected at the bottom of the tank. Where rust is filtered out a positive circulation path might be employed to advantage.

Deaerating

The boiling methods are usually referred to as deaerating processes. In general there are two methods employed:

1. Heating the water and exposing it in a separating chamber which will carry off the air.
2. Application of vacuum to the water which will allow the air to boil out at low temperature.

The first method is applicable wherever steam heat is always available and the deaerating takes place by raising the temperature of the water to a point just below the boiling point in a special steam heater equipped with automatic devices for regulating the level of the water, the temperature of the water and the flow of the steam.

The vacuum system, which involves machinery such as vacuum pumps, is only used in power plants or in places where it is necessary to remove oxygen from cold water. The deactivating process is too slow for cold water. It would require a deactivating tank too large to be practicable.

The boiling system is more effective in removing oxygen than the deactivating system, because it takes up less space and it passes all the water through the same process. Consequently it is less upset by variations in demand for water. The disadvantage of the system is that it requires either steam or the operation of vacuum pumps, and therefore must be given attention at regular intervals.

The deactivating system is an apparatus with few refinements and requires attention only at prolonged intervals, but a deaerating system requires practically continuous attendance. In a power plant or in a large building where steam is always available, the matter of attendance is not serious.

A properly designed and properly operated system for removing oxygen will lengthen the life of hot water piping. Therefore, a building which is already equipped with iron pipe may find it profitable to postpone temporarily the renewal of the whole system.

It is a fact that corrosion in an iron or steel piping system cannot be totally eliminated by deaerating or deactivating, even with a perfect system, because of the dissolving power of the water itself, the impracticability of removing oxygen from cold water, and the impossibility of stopping corrosion where leaks occur. The only answer at the present time to all these difficulties is a complete installation of brass pipe.

Consequently the architect or engineer specifying for new construction will find brass pipe to be the proper answer to his corrosion problem, because it is practically corrosion proof and equally suitable for cold and hot water service.

PLUMRITE BRASS PIPE

Brass Pipe for Fresh Water Service

Properly made brass pipe will last indefinitely in hot or cold fresh water service. Examples, prove that, after twenty years or more of active service, there is no noticeable sign of corrosion.

While no corrosion failure has been recorded, there have been brass pipe failures due to improper manufacture of the pipe, or to the use of inferior fittings, or to installation by incompetent persons. With brass pipe all thought of having to repipe in a comparatively short time or compromise by installing a temporary check to corrosion may be eliminated. It does seem more like common sense to foresee and avoid the trouble in the first place than to depend upon introducing some costly corrective measures when trouble comes.

Bridgeport Experience

In the early days the brass was melted in crucibles, cast into shells and drawn into pipes of the proper size. When the master caster conducting all the operations of mixing, melting, stirring and pouring of the brass felt fit, and did his work well, and when all the fabricating operations were made in accordance with the best knowledge of the state of the art, and the annealing temperatures and time of annealing were just right, the result left nothing to be desired. Naturally, the quality of the product under such conditions depended upon a number of personal factors.

Today the Bridgeport Brass Company mixes the ingredients from systematically analyzed stocks in carefully checked proportions, and melts them in electric furnaces which automatically stir the mixture more thoroughly than can the most expert operator.

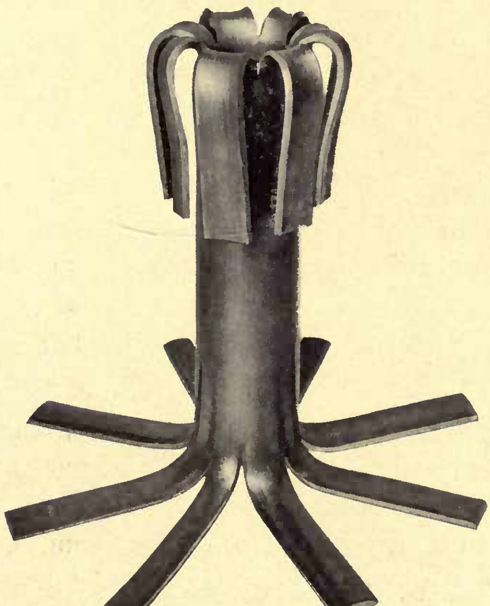


Figure 9. Test demonstrating the ductility of Bridgeport Plumrite Brass Pipe.

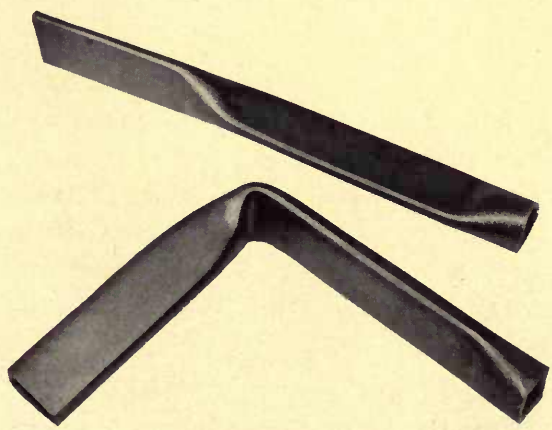


Figure 10. Bridgeport Plumrite Brass Pipe may be bent or hammered cold without cracking.

The melting takes place in a controlled atmosphere free from contamination by gases of combustion, and the pouring is accomplished by a simple mechanism which provides accurate control even in the hands of an unskilled man.

From the raw materials to the finished product every step is carried out with an astonishing degree of uniformity, controlled at every point by accurate observations. Annealing takes place at a definite temperature and for a definite time. The various drafts are made in accordance with predetermined schedules based on extended research and many years of experience.

The only difference between Plumrite brass pipe today and that made in the early days is that formerly the pipe was Plumrite *most* of the time, while today it is Plumrite *all the time.*

Desirable Characteristics of Brass Pipe

The reason for using brass pipe in fresh water supply systems is to provide installations which will last as long as the buildings of which they are a part. To be wholly satisfactory the brass pipe must therefore meet this requirement. The main factors which determine the success of brass pipe installation are:

1. Uniform composition to prevent concentrated electrolytic action and to distribute whatever corrosion may take place.
2. Freedom from internal stresses due to careless or improper fabricating methods, such stresses sooner or later causing cracks known as "season cracks."
3. Proper temper to facilitate bending.
4. Proper composition to facilitate threading.
5. Threads cut with sharp tools and joints made up without the use of excessive quantities of "dope."
6. High-grade fittings with properly cut threads and free from mechanical flaws.
7. Provision for expansion and relief of the joints from excessive tension.

Plumrite is manufactured to meet the above requirements, and to this point the manufacturer can control his product. It is especially important, however, that pipe installations be made by competent plumbers or under the supervision of able technical advisers.

Figure 11. A piece of Plumrite Brass Pipe hammered flat without cracking, demonstrating ductility and softness.

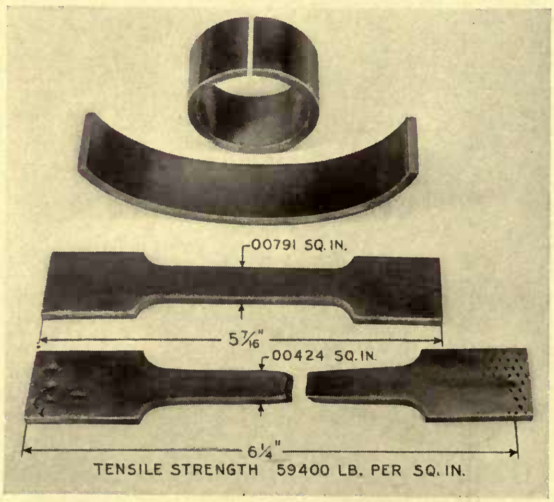


Figure 12. A piece of Plumrite Brass Pipe cut into four equal parts each treated as shown above, demonstrating ductility and strength. Elongation is 45% in one inch and 38% in two inches.

MANUFACTURE OF PLUMRITE BRASS PIPE

Since the quality of brass pipe is so largely dependent upon the processes of manufacture and the accuracy and effectiveness of the control of such processes, it may be of interest to those upon whom fall the responsibility of specifying brass pipe to know the procedure adopted by the Bridgeport Brass Company.

Composition The proportions of the elements in brass influence to a marked degree the physical characteristics of the brass pipe, especially in its workability and its immunity from season cracking. Great precautions are taken to control the relative amounts of the various ingredients. Each ingredient is weighed by a separate operator and the total charge is then checked in a final operation, in which the combined weight is compared with the sum of the component weights. A line-up of weighing machines is shown in Figure 13.

To maintain the purity of the metal,

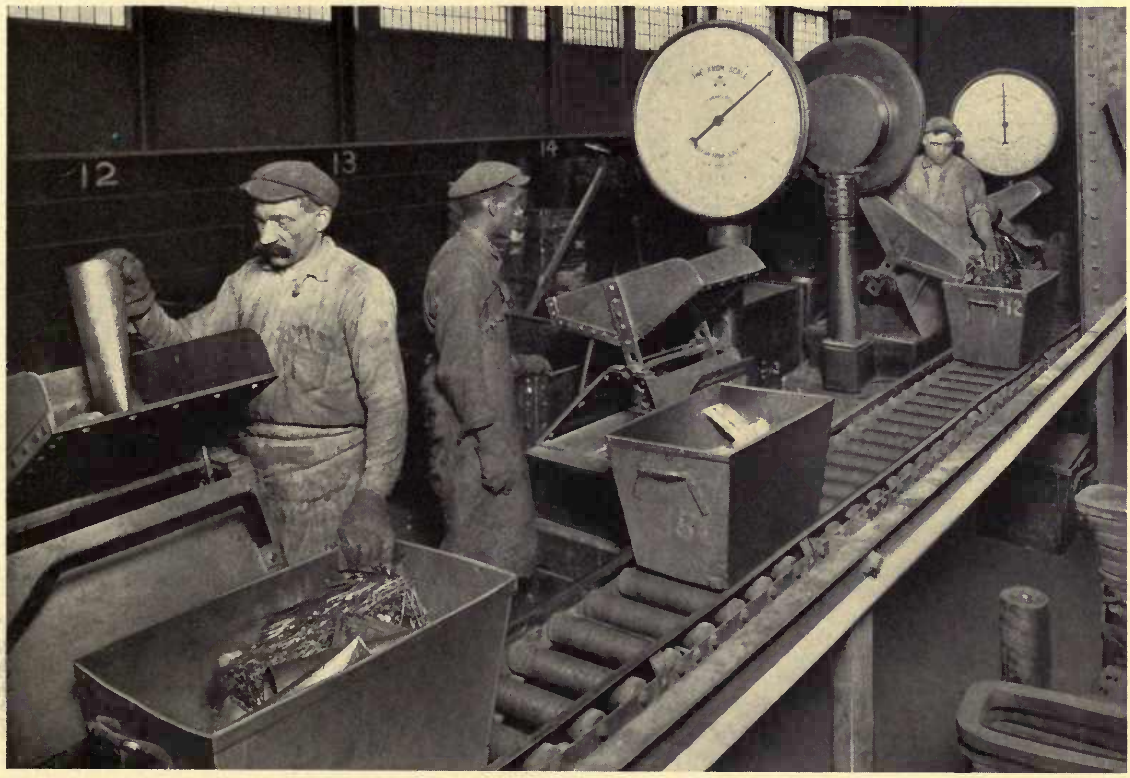


Figure 13. A line of weighing machines handling the ingredients of Bridgeport Plumrite Brass Pipe. Each man has charge of only one ingredient and has to remember only one weight. In the background are seen bins which contain raw materials classified by careful analyses. It is scientific organization of this end of the casting shop that insures an extraordinarily high degree of uniformity in the composition of Bridgeport Plumrite Brass.

the operation of melting must preclude the possibility of contamination. The special electric furnaces used by the Bridgeport Brass Company insure against contamination during the process of melting, because melting takes place in an enclosed chamber wherein the atmosphere is controlled.

Mixing It is not sufficient to have pure ingredients in the proper proportions, but the mixture itself must be intimate and uniform throughout. In other words, no matter how small a piece of brass is taken out, it must have exactly the right proportions of the ingredients, otherwise when fabricated into pipe it will have hard and soft spots resulting in electro-positive areas. Good threading and bending qualities and freedom from season cracking and corrosion demand proper mixing.

Bridgeport furnaces are designed to stir the metal automatically and continuously, thus insuring a uniform and intimate mixture. In fact, it is quite impossible to make a more perfect mixture than is produced in these furnaces.

Lead furnishes an excellent means of checking the perfection of the mixture because, when mixed with copper and zinc by crucible methods to form brass, it is present in particles of variable size, non-uniformly distributed, and tends to settle to the bottom. There is only a small amount of lead in Plumrite Brass, and the mixture is so thorough that it is not easily distinguished in a photo-micrograph. Consequently, to demonstrate the thoroughness of the mixing abilities of Bridgeport furnaces, a sample of Ledrite Brass,* high-lead brass, is enlarged by the photo-micrograph shown in Fig. 14. The little black dots are the lead.

Plumrite brass is shown by the photo-micrograph in Figure 15. Its lead con-

Figure 14. Photo-micrograph of Bridgeport Ledrite Brass. The black dots indicate the fine subdivision and the uniform distribution of the lead and in this way prove the superior mixing qualities of the Bridgeport electric furnace.

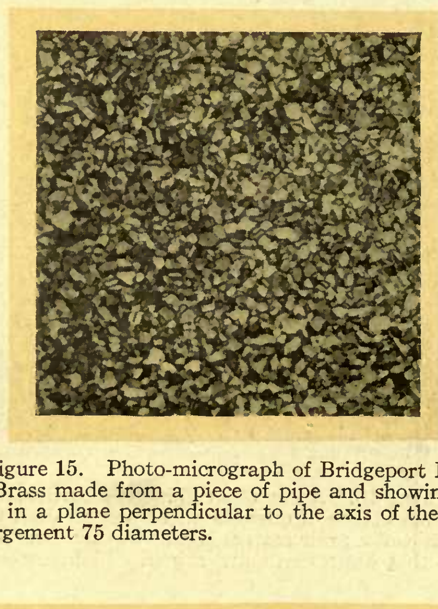
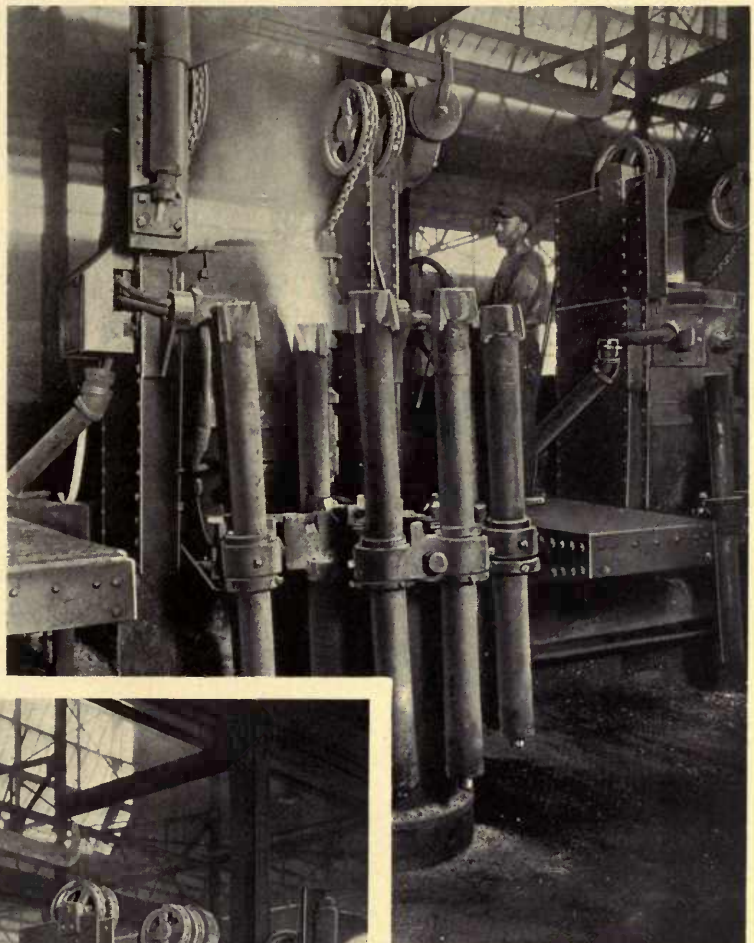


Figure 15. Photo-micrograph of Bridgeport Plumrite Brass made from a piece of pipe and showing the grain in a plane perpendicular to the axis of the pipe. Enlargement 75 diameters.

Figure 16. Pouring billets for Plumrite Brass Pipe.



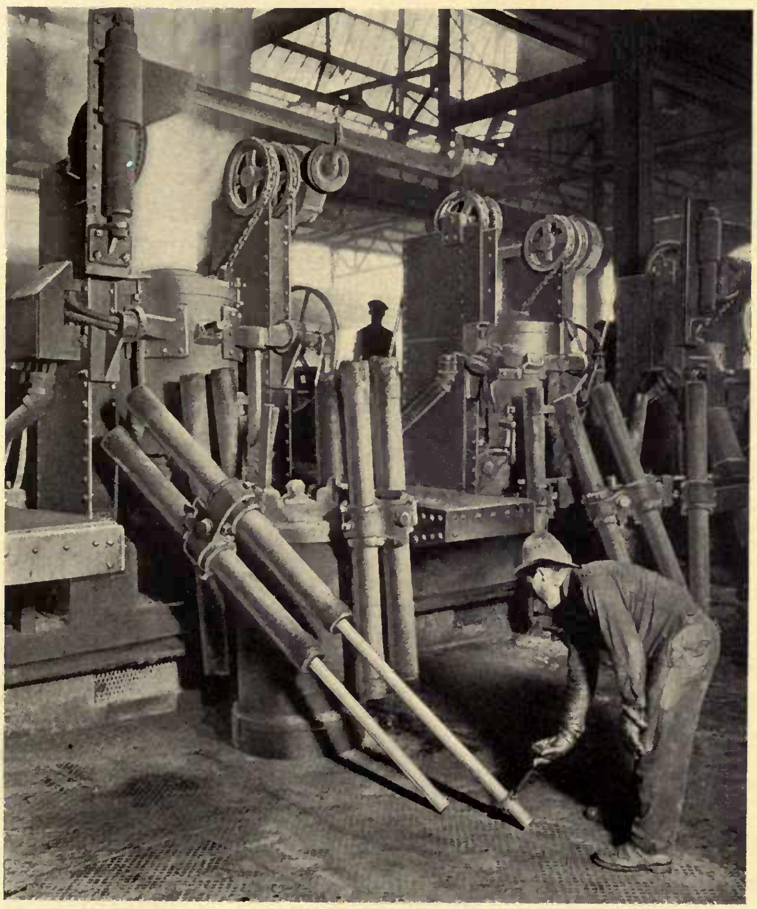


Figure 17. Removing Plumrite brass billets from molds.

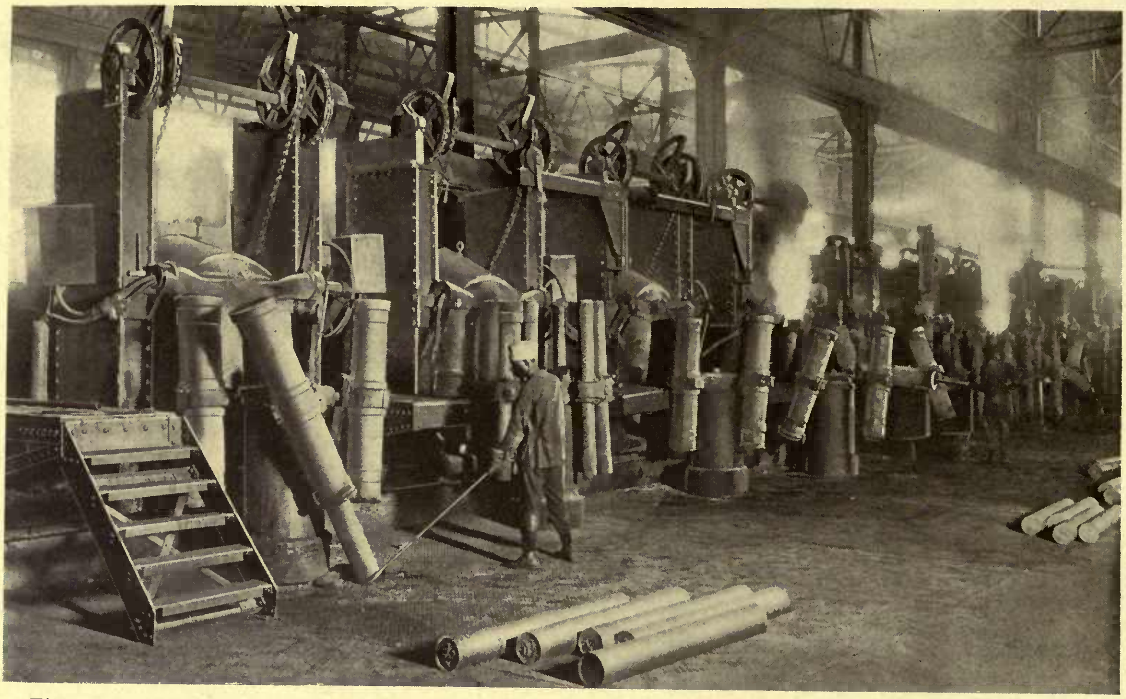


Figure 18. The Bridgeport Brass Company was the pioneer in the successful utilization of the electric furnace for the commercial melting of brass. One of the basic reasons for the high degree of uniformity maintained in Bridgeport Plumrite Brass Pipe is due to the superior results obtained with properly designed electric furnaces.

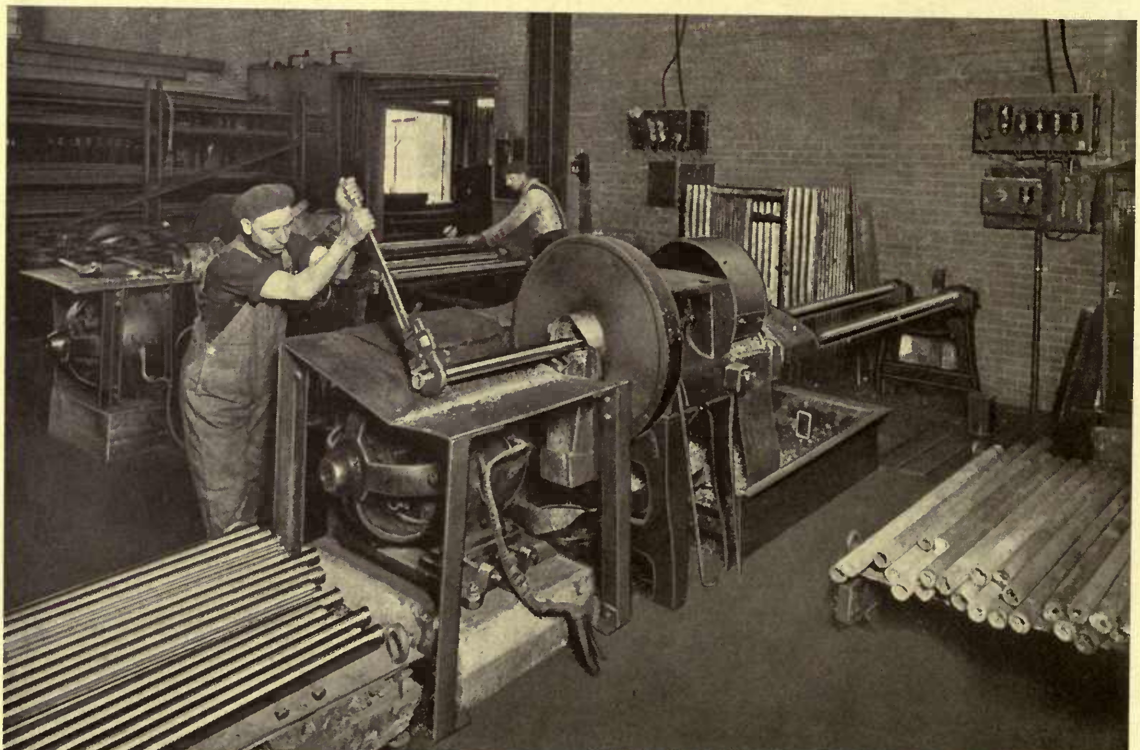


Figure 19. Taking a cut off Plumrite billets to assure flawless surface in finished pipe; finished billets at left, rough billets at right.

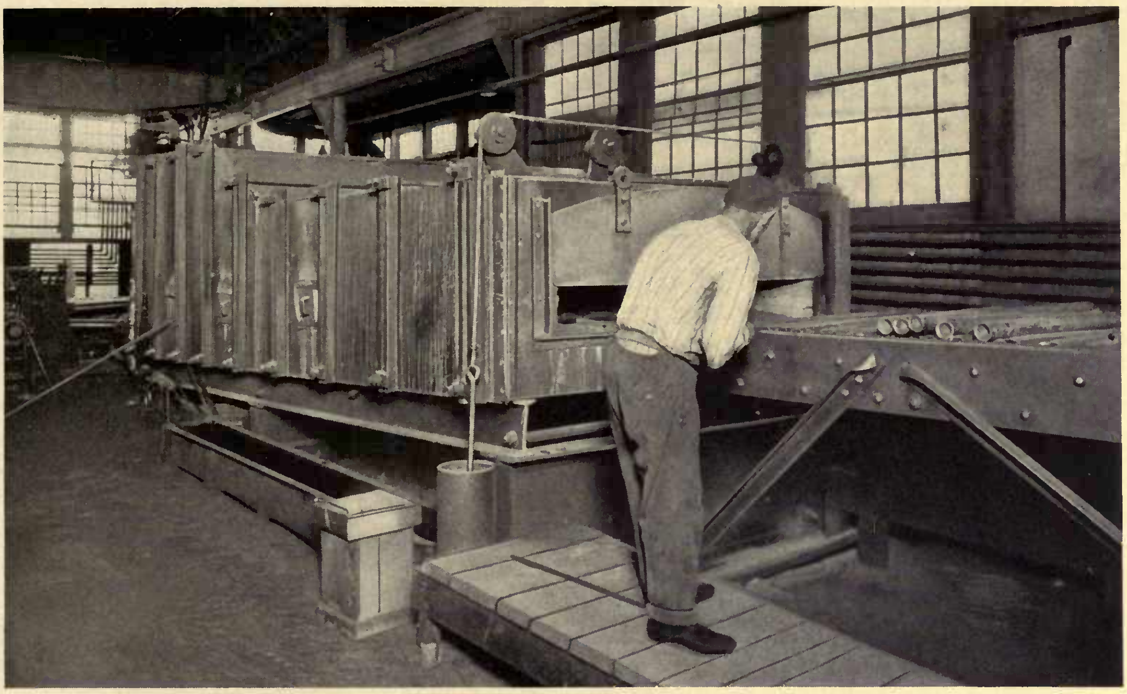


Figure 20. Plumrite billets entering the heating furnace on the way to the piercing machine.

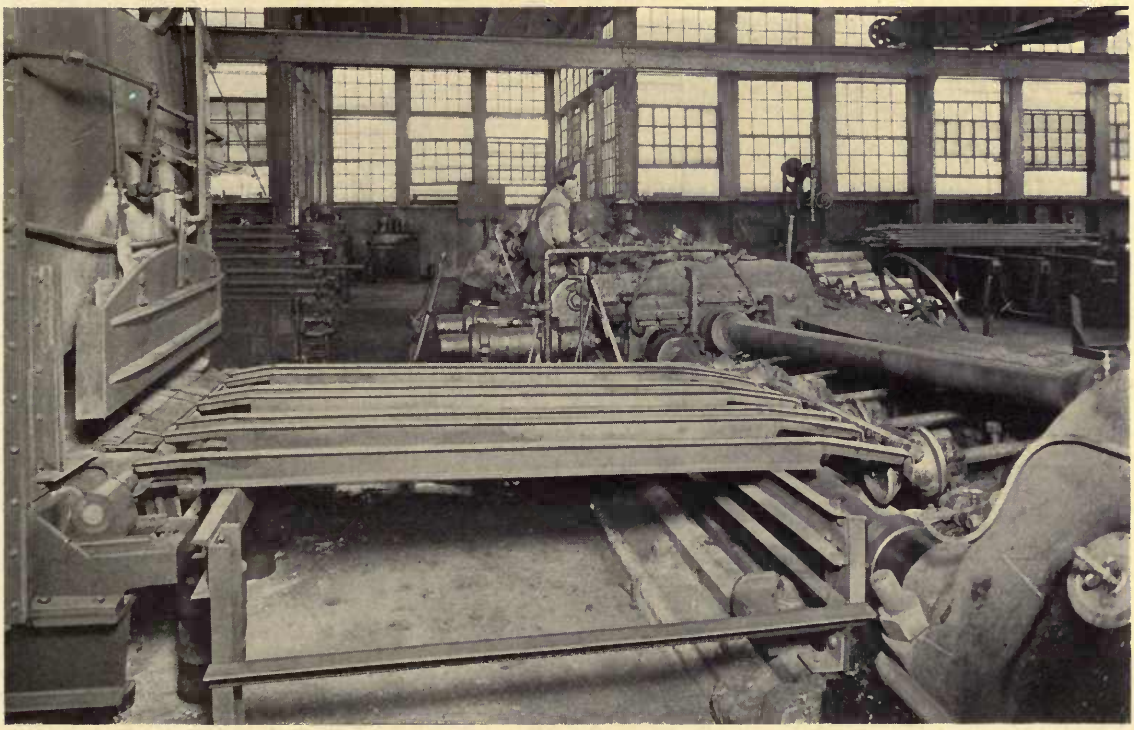


Figure 21. A hot Plumrite billet has just left the heating furnace shown in Figure 20 and is about to enter the piercing machine, where it will be subjected to the cross-rolling action of three rolls placed at an angle to the axis of the billet and in such a way that the point of contact describes a spiral drawing the billet forward. Just as the billet leaves the rolls it encounters a hardened point over which it is forced to travel, the function of which is to open up the billet and form it into a tube.

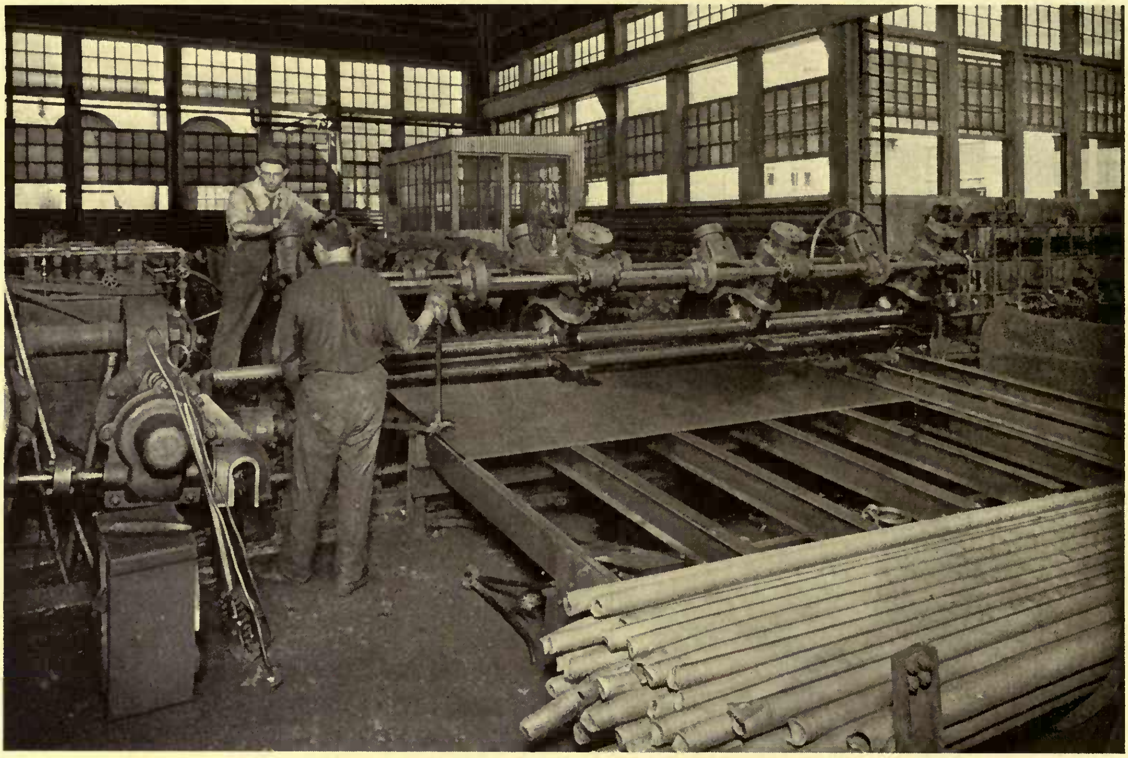


Figure 22. The pierced Plumrite tube is seen emerging from the rolls and passing over the rod which carries the piercing point. One of the points which has been removed for repair is shown lying on a bench in the left foreground. Finished tubes ready to go to the tube drawbenches are shown in the right foreground.

tent is only 0.35 per cent. Care must be exercised in maintaining the proper amount of lead because too little lead impairs the free-cutting qualities of the pipe in the threading operation, and too much lead will cause season cracking.

Sampling To insure correctness and uniformity of mixture, samples are taken of every heat and tested before the heat is started on the cycle of fabricating operations.

Pouring The melted brass, when it has reached the proper temperature is poured into special molds held in definite position with relation to the spout of the furnace. The various mechanical arrangements are such that a man can control the operation of pouring perfectly and produce uniform results day in and day out. The various factors entering into the manipulation of the pouring stream in relation to the mold have an important bearing on the quality of the casting. If the casting is not free from mechanical imperfections trouble will follow in the subsequent operations.

Piercing The brass is cast into solid billets, from which cylindrical shells are made by piercing a hole along the axis of the billet. In order to insure a surface on the finished

* Ledrite Brass is a Bridgeport product developed especially for rod used in automatic screw machines. By systematic testing of every heat it is kept true to mixture.

pipe free from mechanical defects, the surface of the billet must be prepared before the piercing operation is begun. Two processes are employed by the Bridgeport Brass Company.

1. Heating the billet to the plastic temperature and forcing it through the die of an extrusion machine.
2. Placing the billet in a lathe and removing the surface with a cutting tool.

The two methods are equally good when properly performed.

The piercing operation is both interesting and rather spectacular. Billets are heated to the plastic temperature in a furnace, as shown in Figure 20. They then pass to the piercing machine. The working parts of this very interesting machine consist of two power-driven rolls mounted at an angle to one another, their surfaces having the form of the frustrums of two cones. Just below and between these two rolls is a small idler roll. The billet passes between the three and is drawn in by the helical action of the three rolls which gives it a powerful forward motion, forcing it against a projectile-like steel point carried on the end of a long rod which rotates at the same time. Figure 21 shows a billet entering the machine, while Figure 22 shows the tube issuing from the other end of it. Pierced billets may be seen in the foreground at the right.

Drawing

From the piercing mill, and after pickling, the tubes go to the draw benches. Before a tube can be drawn, one end must be made slightly smaller in diameter so that it can be inserted through the die of the draw bench and gripped on the other side. This end reduction is called "pointing" and is illustrated in Figure 23. The pointed tube is then inserted through a suitable die and a plug placed inside of it, as shown

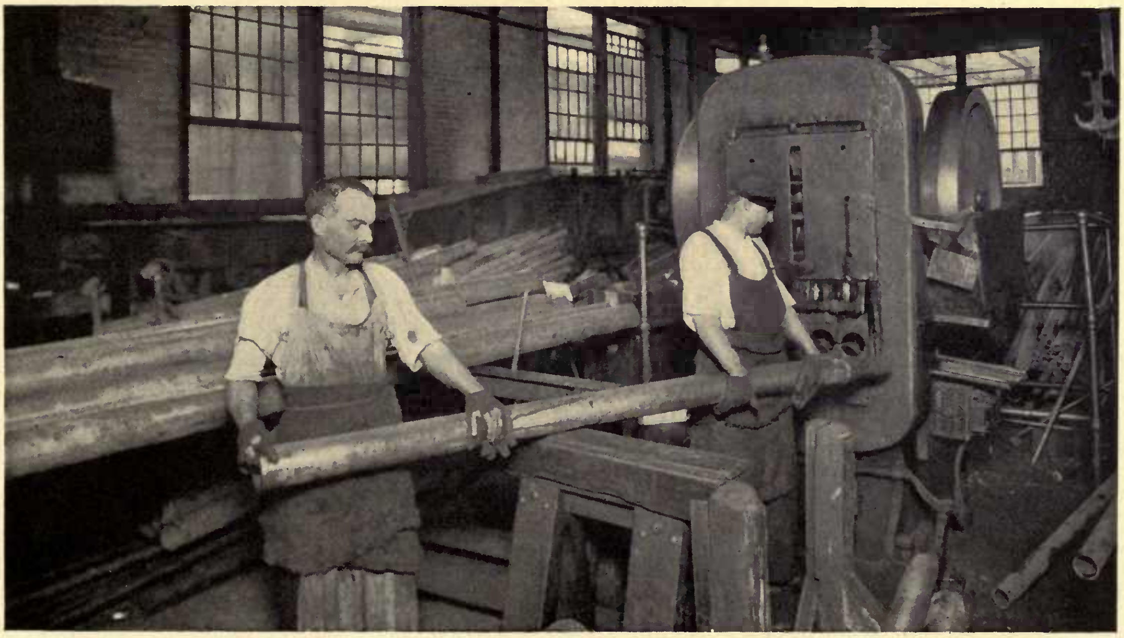


Figure 23. Pointing Plumrite Brass Pipe by hammering one end to reduce its diameter so that it can be inserted into the die of the draw bench.

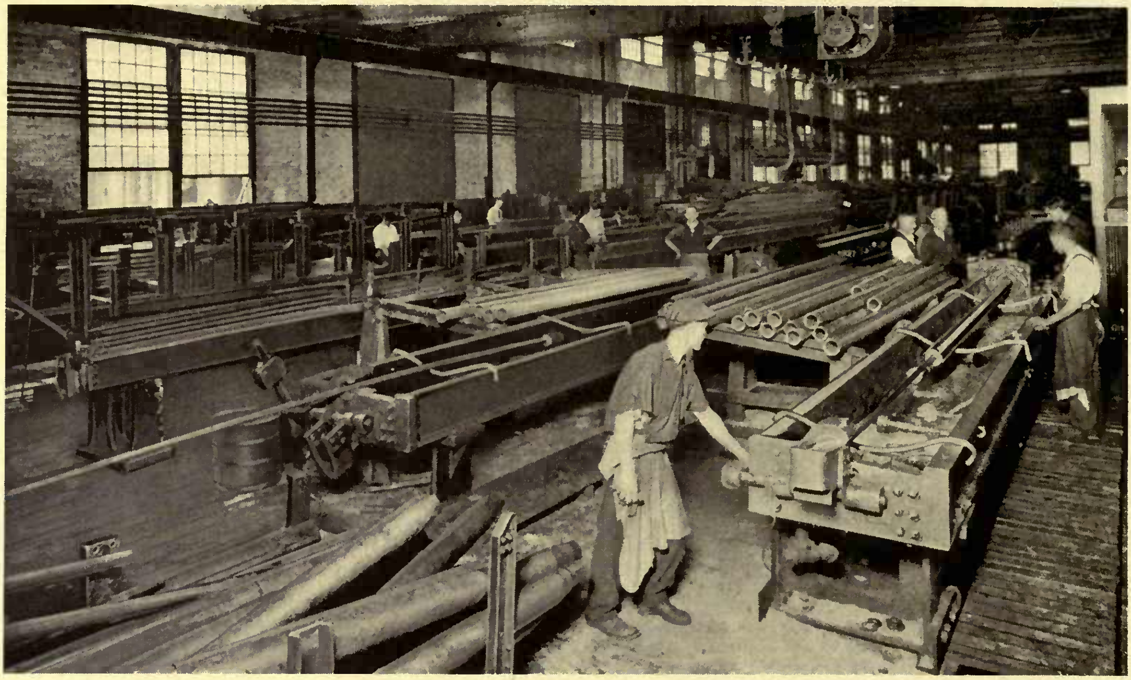


Figure 24. Drawing pipe. At the right a pipe is seen partially through the die. The inside dimensions and the shape of the pipe are maintained by a tapered plug held in the mouth of the die by the rod seen extending from the end of the pipe. It is supported near the end of the pipe by a bushing. The power for drawing is supplied by a long piston working in a cylinder. As soon as a batch of pipe has been passed through the draw bench, it is picked up by a crane and deposited in the annealing department.

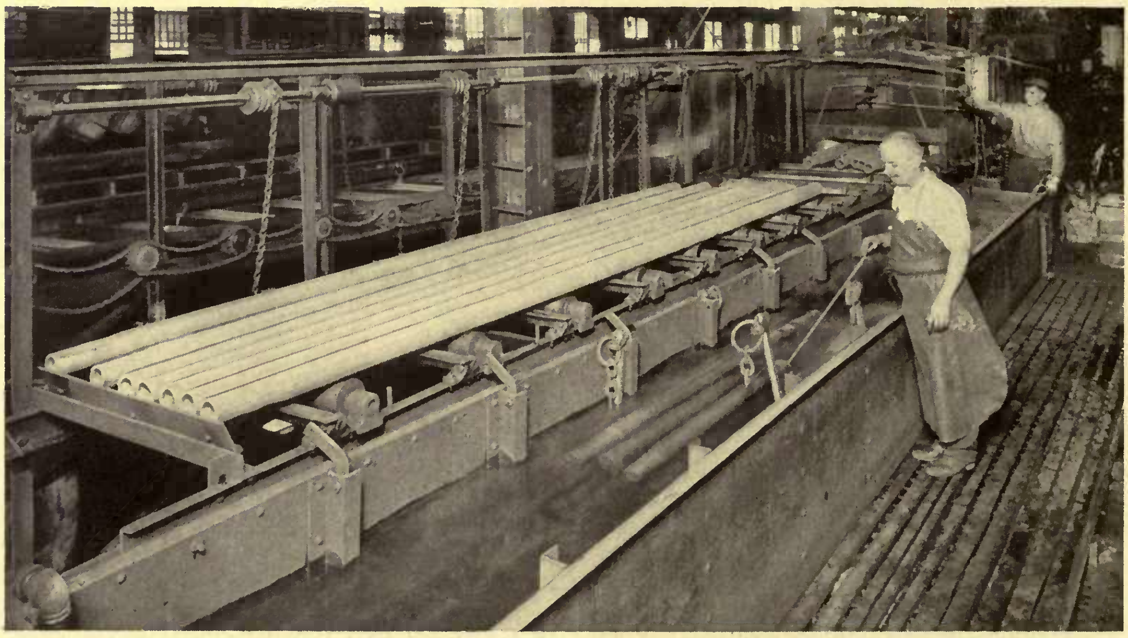


Figure 25. A batch of Plumrite pipes issuing from a continuous annealing furnace. The method by which the conveying rolls are driven is plainly shown in the machine just back of the one in the foreground. The Plumrite pipes here shown are just about to be dumped into the pickle which is accomplished by the operator in the background. The temperature of the furnace and the speed of travel through them is so chosen, that the mechanical strains from the drawing operation are equalized without detriment to the physical properties of the pipe.

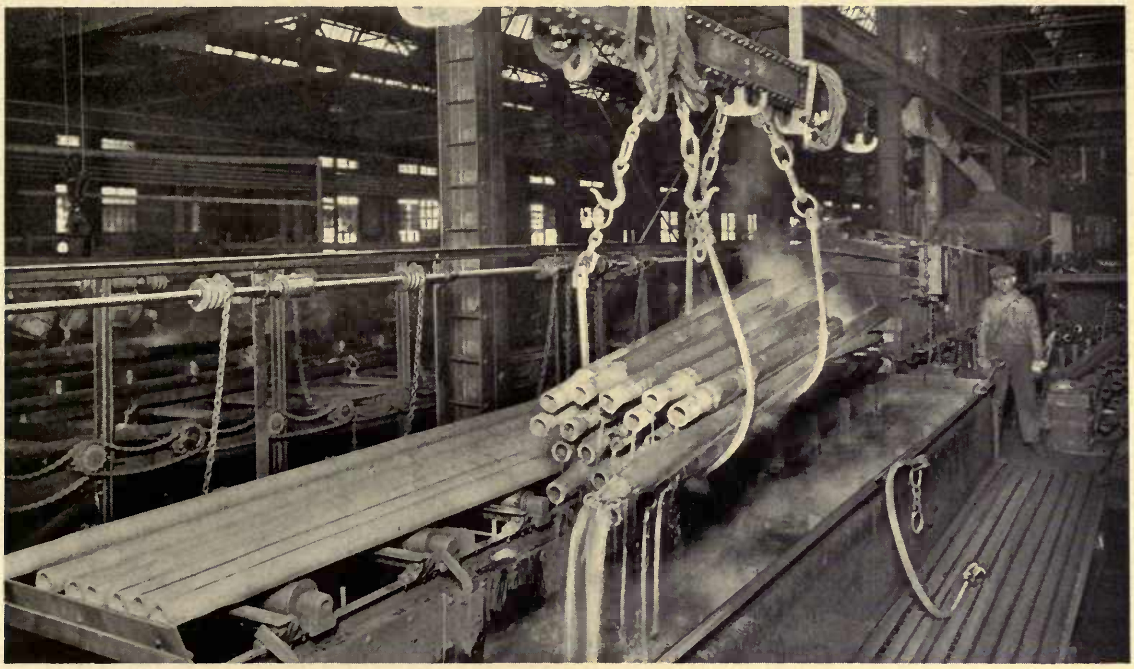


Figure 26. A batch of Plumrite pipe being removed from the pickle to be returned to the drawbenches for the next draw.

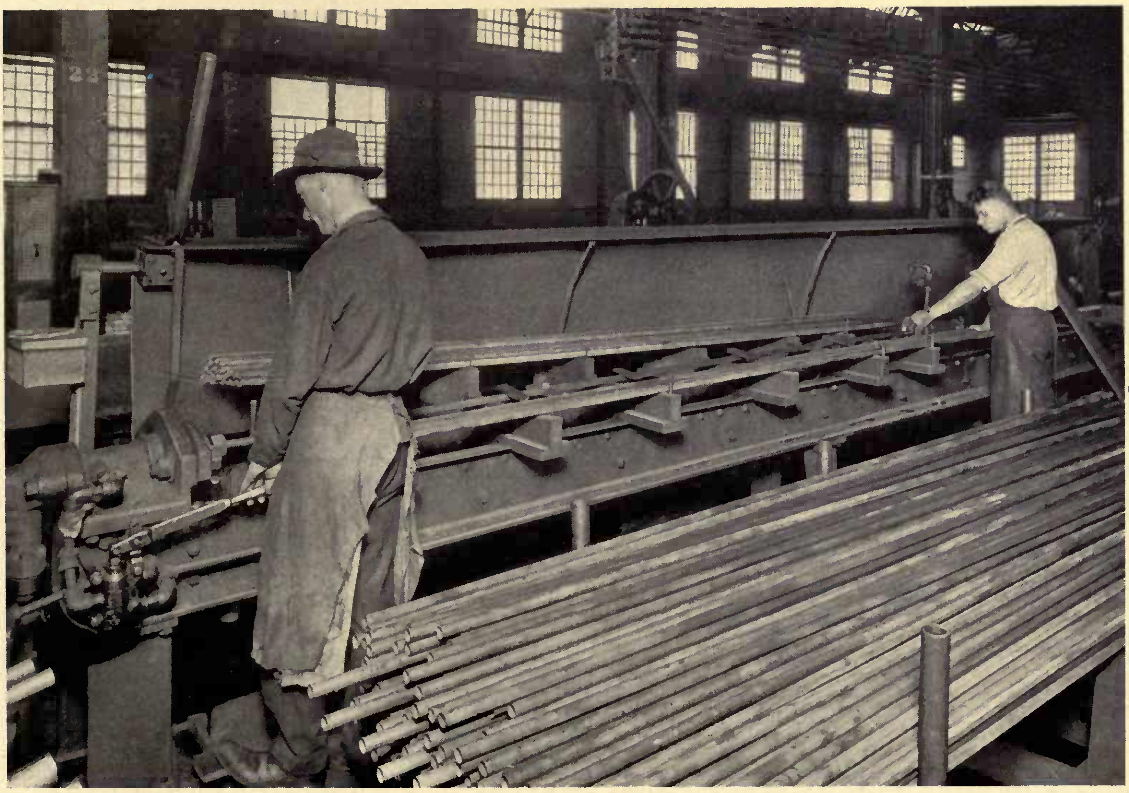


Figure 27. An hydraulic test of 1,000 pounds per square inch is applied to each piece of Plumrite Pipe.

in Figure 24. The grip of the draw bench, which may be operated either by hydraulic, electric or mechanical power, draws the tube through the die and over the plug, reducing its diameter and its wall thickness by a certain specified amount and at a definite rate. One of the important elements in this process is the use of special lubricating means and specially designed dies, both of which factors affect the amount of stress to which the metal is subjected, which in turn affects the properties of the finished pipe. This entire operation is performed cold.

The Bridgeport Brass Company maintains a large research department and control laboratory, one of the functions of which is to develop and control the quality of these lubricants, also the quality and accuracy of the dies, so as to maintain uniform results at all times.

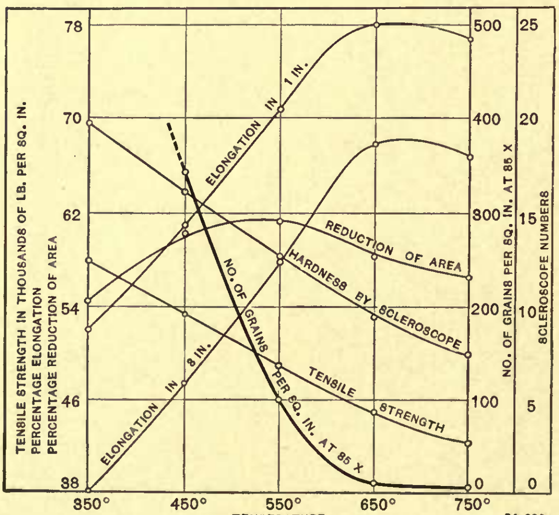


Figure 28. Diagram showing effect of annealing temperature upon physical properties for brass for a given composition.

Annealing and Pickling

After each draft the tubes are delivered to continuous annealing furnaces held at constant temperature, the tubes traveling through the furnaces at a definite speed. In Figure 25 a set of tubes on the conveyor has just emerged from the furnace and is ready for pickling. Figure 26 shows a bundle of tubes being lifted from the pickle to be carried to the draw benches for the next operation. This operation of annealing is of the greatest importance, since it has a marked effect on the distribution of stresses in the walls of the tube and is the preventive of what is known as "season cracking."

The importance of proper annealing

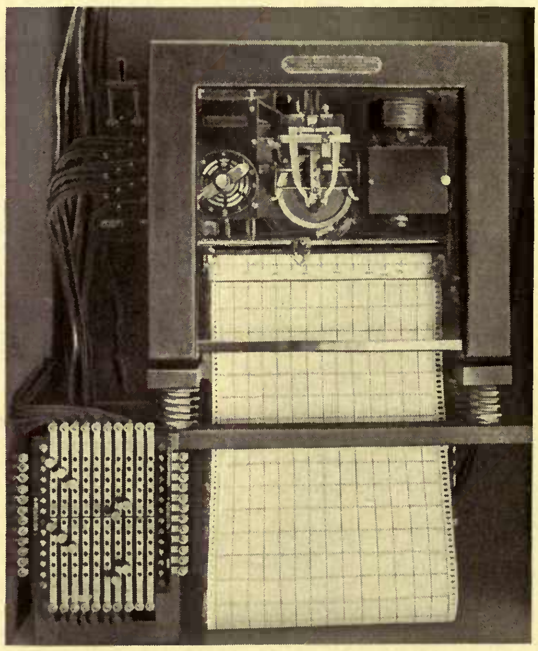


Figure 29. A recording pyrometer which automatically records the temperature of a group of annealing furnaces. By means of this instrument, an accurate record is kept of each batch of metal so that the control laboratory can always trace the history of samples taken for the purpose of controlling mill operations.

cannot be over-estimated. Bridgeport Brass Company has studied the annealing operations with respect to temperature, rate of heating and cooling, and as a result of these studies has formulated exact specifications covering both these factors. In Figure 28 the result of experiments on a certain alloy are shown graphically. From this diagram it is seen that the annealing temperatures affect vitally all the physical properties of the metal, and when properly controlled certain desired properties can be obtained.

The temperature of the annealing furnaces is measured by electric pyrometers, the indicating instruments being used by the operators for making heat adjustments, while the recording instruments serve to provide an exact history and permanent record of any given batch. In Figure 29 is shown one of the recording instruments.

Testing

After straightening, the ends of each pipe are sawed off, resulting in a *variety of pipe lengths.* This is an advantage as well as an economy because there is less waste of labor and material in cutting up and threading pipe on one job. While users often specify given lengths of pipe it is recommended that "random" lengths within reasonable limits be accepted, since it enables the selection of pieces without the attendant waste of time and material so frequently resulting from carrying out an installation with only one specified length of pipe available.

Every piece is next subjected to an hydraulic pressure test of 1000 lb. per sq. in., as shown in Figure 27. In addition to the pressure test each piece of pipe, *just before delivery to the shipping department,* is examined by an expert and checked for *general* quality.

Figure 30. Bridgeport Plumrite Brass Pipe is always in stock in a great variety of sizes.

SEASON CRACKING

Occasionally brass pipe has been known to fail after installation due to the occurrence of spontaneous longitudinal cracks which extend clear through the wall of the pipe, causing it to leak. This action is due to the existence of internal stresses set up within the wall of the tube during the process of manufacture. The cause and nature of these stresses has only recently been determined.

Unsuitable materials and unskilful methods of manufacture are the primary causes of this trouble. Specifications which are sufficiently complete to insure brass pipe that can be guaranteed against season cracking cannot be written except by men having special training in brass manufacture, and data such as is required is not available to those outside of the industry. Therefore, engineers and architects buying brass pipe should go to manufacturers who know the brass pipe business and who will guarantee their product against season cracking.

Fortunately, it is possible to test brass pipe after its manufacture is completed, and determine whether or not internal stresses sufficient to produce season cracking are present. While Bridgeport methods are such as practically to preclude the existence of internal strains, all Bridgeport pipe is actually tested for season cracking stresses before shipment.

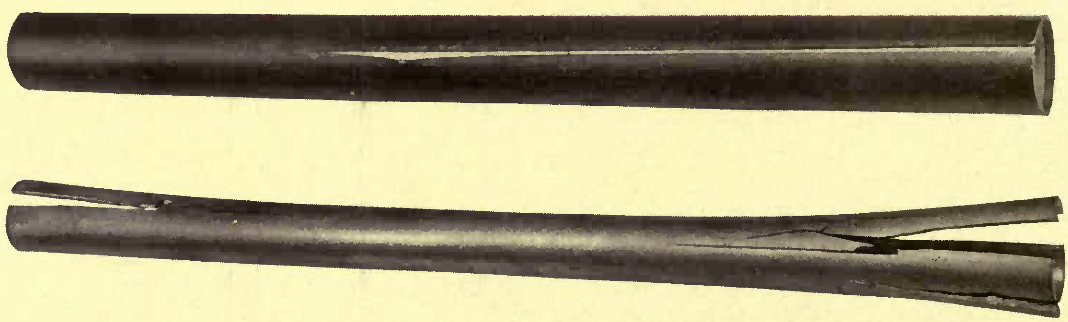


Figure 31. Specimen of hard brass pipe that season-cracked in service.

Figure 32. Less than 15 minutes immersion in mercurous nitrate solution caused this hard pipe to season crack.

DESIGN OF BRASS PIPING

To give rules for designing hot and cold water distribution systems, or even to discuss the relative merits of different methods of distribution is beyond the scope of the present treatise. There are, however, certain details of water service piping that merit special attention wherever brass pipe is to be used or considered.

Pipe Size

The determination of pipe sizes for water service mains, risers and branches is more often a matter of experience than of scientific calculation of friction and flow. Each plumbing engineer has his own methods of arriving at the result, and almost without exception the practice is based upon experience with iron and steel pipe.

The first step in pipe size determination is to estimate the water consumption of the building, allotting the proper quota to each fixture. Naturally it is impossible to assign a definite consumption to each fixture of a bathroom or kitchen that will correctly represent the actual requirements, unless the choice is tempered with good judgment based upon local conditions of use.

One of the leading plumbing designers in New York City uses the figures shown in Table IV for his first estimate of water requirements and then, to allow for the fact that all fixtures are not used simultaneously, divides by three to get the actual flow carried by the service pipes in public buildings and hotels; in private residences the same figures are divided by four.

TABLE IV

WATER CONSUMPTION OF SUPPLY FIXTURES

Fixture	Service	Consumption Gal. Per Hr.	Maximum Flow Gal. Per Min.*
Basin	Hot and Cold	10	5
Bathtub	" " "	30	10
Shower	" " "	40	10
Toilet	Cold	7	5
Flushometer	"	7	60
Urinal	"	6	5
Sink	Hot and Cold	10	10
Washtub	" " "	10	10
Slop-sink	" " "	20	10

* This column taken from article by T. N. Thomson, "Plumber's Trade Journal," June 15, 1922, Page 949.

Allowance for Corrosion

On account of corrosion which clogs iron and steel pipes and reduces the flow even to the point of plugging the pipe entirely, sizes smaller than ½ inch are never used. Therefore, in iron and steel pipe installations ½-inch pipe is used for connection for practically all fixtures except bathtubs, slop-sinks and flushometers.

When it comes to the branches that supply a number of fixtures, practice again seldom permits the use of pipe smaller than ¾ inch. In fact, if there are more than three fixtures on the branch there should be 1-inch pipe or larger.

Brass pipe has the great advantage of not requiring any allowance for reduction of area by corrosion. The pipe can be chosen wholly on the basis of carrying capacity, because it will retain its initial capacity throughout its life.

Brass Pipe Size

Few plumbing engineers have ever taken full advantage of the sustained carrying capacity of brass pipe, but some leading engineers have a rough rule by which they design for steel and then use the next size smaller for brass.

One of the largest life insurance companies maintains an engineering department to study, criticise and pass on specifications for buildings for the construction of which it makes loans. This company requires brass for hot water and all concealed work except in unusual cases. If iron or steel are used the pipe must be one size larger than brass. Brass pipe as small as ⅜ inch is permitted for fixture connections and branches where its carrying capacity is sufficient; but no iron pipe smaller than ½ inch is permitted.

In choosing the size for mains and risers in large buildings, the friction loss should be taken into account. At no point in the system should the pressure be less than 8 lb. per square inch. For flushometers it should not be less than 10 lb. per square inch and preferably not less than 15 lb. per square inch. The loss in feet of static head for different sizes of clean iron pipe and different discharge rates is given in Figure 34. These figures can be translated into pressure by using the conversion factor 4.33 lb. per square inch = 10 ft. head.

The size of riser may be easily determined for the first approximation by making a rough diagram as in Figure 33, showing the floors and entering the average quantity of water in gallons per minute at each branch. Consider a 10-story building with a branch at each floor and each branch above the first floor requiring a flow of 15 gallons per minute. The flow at each branch, beginning at the top, is entered as shown in the diagram and the sum of the flows in the branches is shown in the riser at each floor.

Assuming a city water pressure of 70 lb. per square inch in the basement and a height of 115 feet to the highest fixture, 115 feet represents a static head of 0.433 times 115 = 50 lb. per square inch. Therefore, only 20 lb. per square inch is available at the top floor, and if a pressure of at least 15 lb. per square inch is required, not more than 5 lb. per square inch or 11.5 feet in friction can be lost; that is, not more than 10 feet per 100 ft. of riser.

Referring to Figure 33 it is found that 185 gallons per minute with a loss of 10 feet corresponds to 3-inch pipe. Therefore, the riser starts at 3 inch. Following the 10-foot friction line vertically, it crosses the 2½-inch pipe size at 115 gallons per minute. Therefore, 3-inch pipe continues to the third floor where it is changed to 2½ inch. In the same way the 10-foot

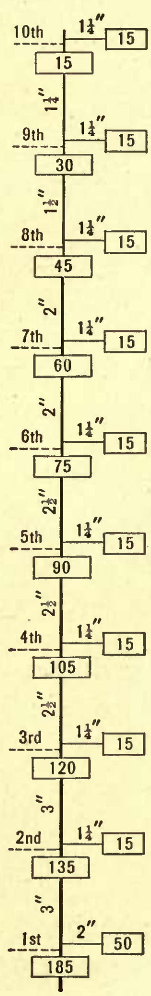


Figure 33. Schematic layout for determining riser pipe sizes. The flow in gallons per minute at each floor is entered and the gallons per minute in the riser is summed up just below each floor branch. With this diagram and the charts shown in figure 32 the pipe sizes can be written in with little trouble.

friction line is followed from one pipe size to the next, the change being made at that point in the riser where the flow is less than that indicated by the diagram.

The sizes determined from the friction-flow diagram are ample for brass but with iron some allowance should be made for reduction of area, and increase in friction due to corrosion. Good practice would allow a full size larger all along the line, namely: 3½ inch for 3, 3 inch for 2½, 2½ for 2 and 1½ for 1¼.

Elbows

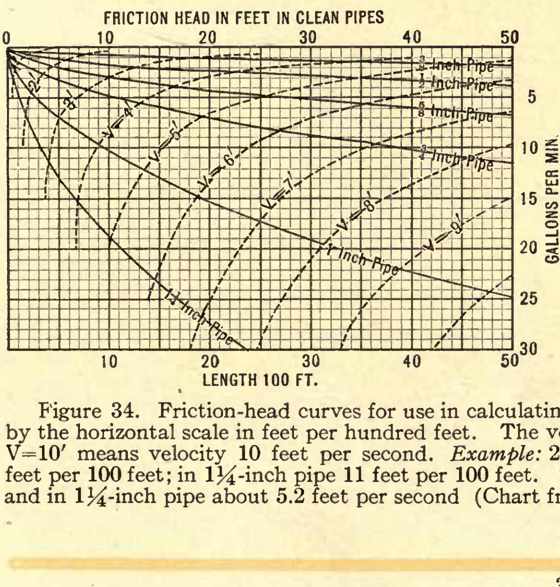
When water is forced to make a sharp turn, such as in an elbow or T, there is a friction loss that may be expressed as an additional length of pipe. A rule given by Walter S. Timmis in the Journal of American Society of Heating and Ventilating Engineers, May 1922, page 402, multiplies the diameter in inches by 40 and divides by 12 to get the equivalent feet of straight pipe which can be figured in the usual way for frictional resistance. The following sizes are worked out by this rule.

Pipe sizes	¾	1	1¼	1½	2	2½	3	3½	4
Equivalent length, straight pipe in feet	2.5	3.3	4.1	5	5	8.3	10	11.7	13.3

Joints

If a piping installation is to give good service, not only must the best materials be chosen, but the system must be correctly designed and properly installed. This is even more true of brass than of steel, because the permanent character of brass makes it possible to eliminate the repairs altogether by careful work at the start.

Couplings between floors should be avoided wherever possible, all joints being made at the branch connections. Brass installations should be thoroughly tested for defective fittings before the pipe is closed in. It is good practice to carry excess pressure on the system as the work progresses.



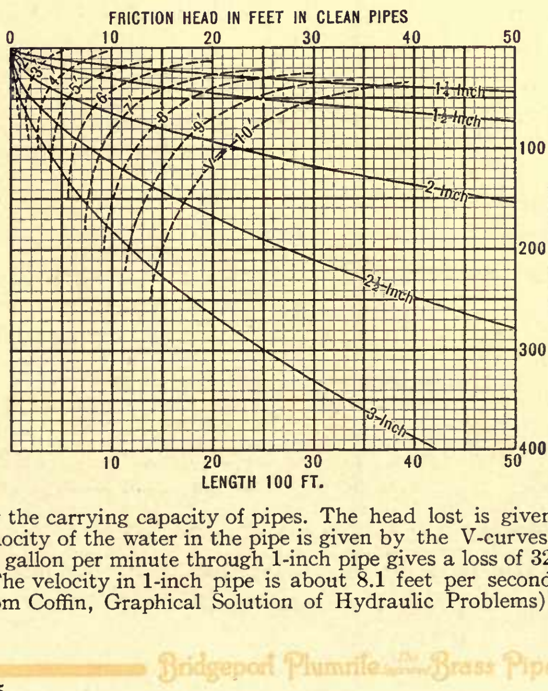


Figure 34. Friction-head curves for use in calculating the carrying capacity of pipes. The head lost is given by the horizontal scale in feet per hundred feet. The velocity of the water in the pipe is given by the V-curves, V=10′ means velocity 10 feet per second. *Example:* 20 gallon per minute through 1-inch pipe gives a loss of 32 feet per 100 feet; in 1¼-inch pipe 11 feet per 100 feet. The velocity in 1-inch pipe is about 8.1 feet per second and in 1¼-inch pipe about 5.2 feet per second (Chart from Coffin, Graphical Solution of Hydraulic Problems).

Expansion

To avoid troubles due to leaky fittings and joints, great care must be exercised to provide for expansion and contraction, especially in hot-water systems. Plumrite brass pipe expands 0.0133 inch per 100 feet for every degree Fahrenheit change of temperature. In hot-water systems it is well to allow for expansion 2¼ inches for every 100 feet of pipe, and in cold water piping approximately ⅞ inch per 100 feet.

Expansion in risers is absorbed by using loops in the pipe. For hot water about every fourth floor should be provided with a loop as shown in Figure 35. Such loops are preferably made by bending the pipe itself to form a U from 3 to 5 feet deep with a radius of 9½ inches. The supports are alternately one side and then the other of the loop, so as to confine the expansion between any two successive points of support, and thus prevent accumulation of expansion along the line. Another method is to support the pipe between loops by means of wrought iron clamps.

Where branches are taken off, provision must be made for free movement of riser and branch. This is best done by a three-plane bend as shown in Figure 36. Such a bend can absorb expansion from any direction without setting up any serious strains in the fittings.

Where branches are taken off in a trough, expansion and contraction are prevented from causing damage by making connections so as to start the branch clear of the bottom of the trough, allowing it to sag into contact with the bottom at some distance from the connection. Then when the riser sinks it can do so without meeting the resistance of the branch pressing against the bottom of the trough. See Figure 37.

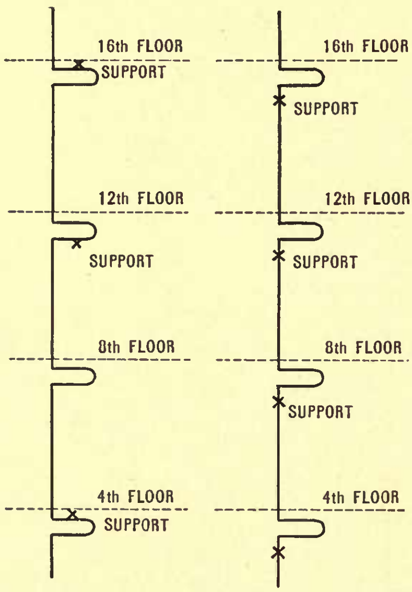


Figure 35. Brass pipe risers should be provided with expansion members at intervals depending upon the temperature changes; for hot water pipe every fourth floor will be found adequate. The loops indicated are from 3 to 5 feet long. The method of support where possible should be in the horizontal leg of the loop and supports should be located on alternate sides of a loop so as to confine the expansion between supports and prevent its accumulating along the line. Where it is necessary to employ supports on the vertical run, a support should be applied between every pair of loops.

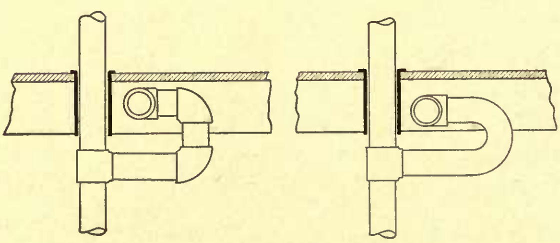


Figure 36. Details of expansion loops. Expansion of the riser itself is taken up in loops as described in figure 35. Branches taken off from risers in hot water systems should also provide for expansion in such a way as to relieve all strains on joints and fittings. Branches taken off with a three-plane bend, made by bending a single piece of pipe, or with elbows and nipples, are free to move in any direction without strain.

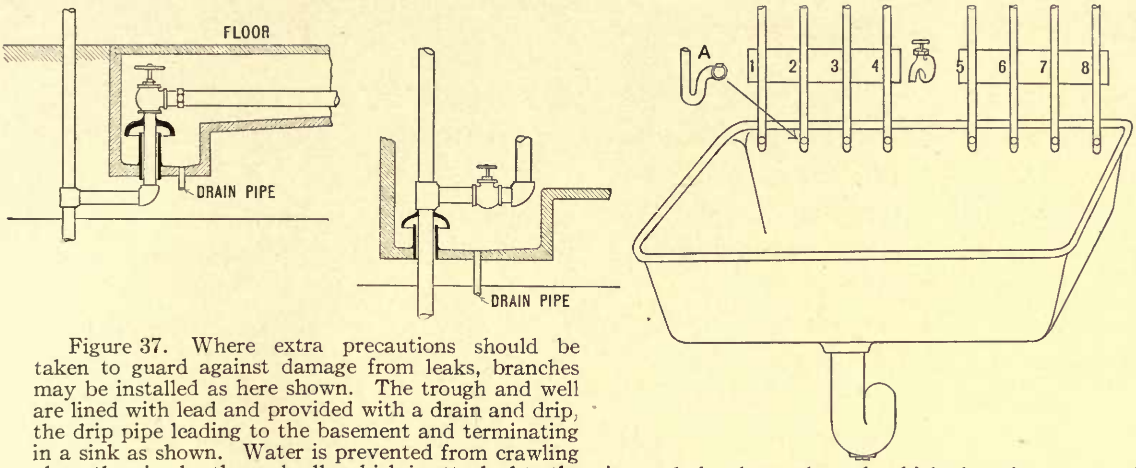


Figure 37. Where extra precautions should be taken to guard against damage from leaks, branches may be installed as here shown. The trough and well are lined with lead and provided with a drain and drip, the drip pipe leading to the basement and terminating in a sink as shown. Water is prevented from crawling along the pipe by the umbrella which is attached to the pipe and the sleeve through which the pipe enters the well makes a watertight joint with the trough so that no leak can occur at that point. The branch is taken off at a point somewhat above the bottom of the trough, allowing the branch to sag by its own weight into contact with the trough, then it is free to go and come with riser without setting up any strains. Drain pipes lead to a sink in the basement, where each drip is provided with a water seal and a drip check as shown in the detail, A. By means of these drips the engineer can tell at a glance just where any leaky valve or fitting is located.

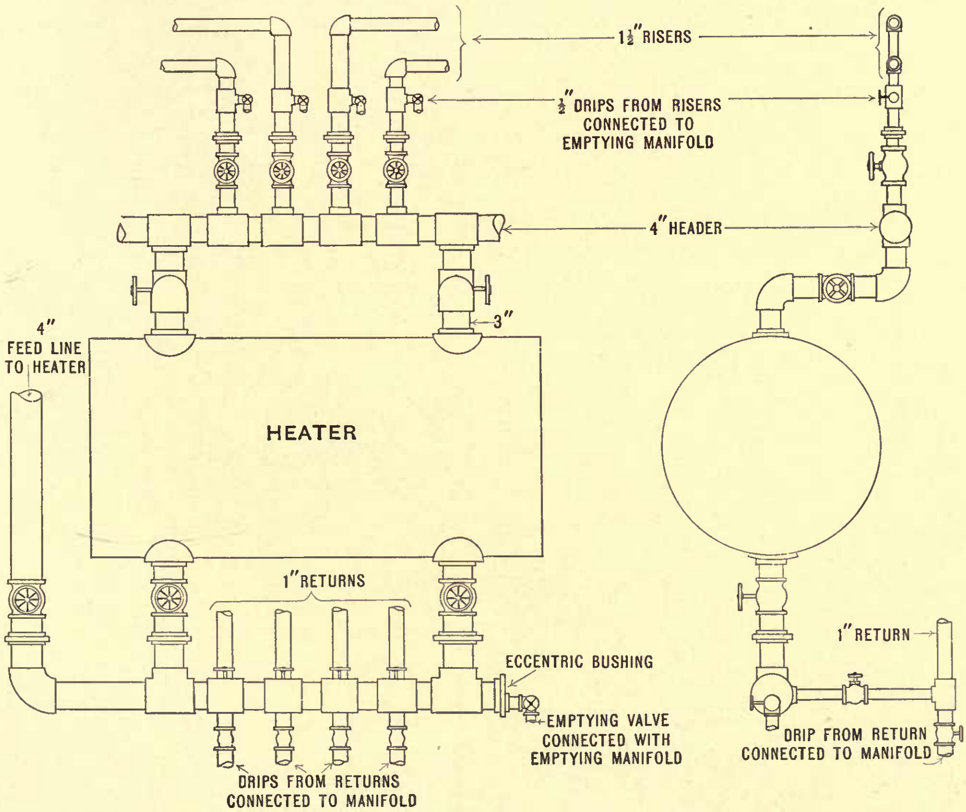


Figure 38. Heater connections to avoid expansion trouble and provide for maintenance of the system with least interruption. It will be noted that expansion in the header between the boiler connections is perfectly swivelled at the elbows, one underneath the header and one on top of the boiler. The risers may lead from the header, either vertically as shown or horizontally where headroom will not permit the vertical arrangement. The valves are so arranged that the heater may be disconnected entirely from the system without interfering with the operation of other heaters connected with the same header. Also each riser may be disconnected and drained without affecting any other part of the system. All drips from risers and returns are led to a drip manifold at some point convenient to inspection by the operating engineer.

HANDLING BRASS PIPE

Many people handle brass pipe in the same way as they do iron and steel. However, since brass pipe properly installed will last as long as the building of which it forms a part, it is very desirable to have the installation not limited in its usefulness by improper handling. On general principles, brass pipe should be handled more carefully than iron and steel, because its high quality shows plainly in its appearance, especially when clean pipe, such as Bridgeport Plumrite, is used. Such a pipe inspires a pride in workmanship and is bound to receive more careful handling than a piece of pipe that is dirty and smeared over with paint and grease.

Cutting Threads

One of the most important operations in handling any pipe is the cutting of the threads. This is especially true in brass pipe because the joints must be of the best if full value is to be obtained from the use of brass pipe. The threads must be clean and accurate so as to make a perfect joint from the start. Slight leaks will not close up by rusting as they do in iron and steel pipe.

Brass pipe used in concealed work may be clamped in sharp steel jaws. Where exposed work or nickel plated pipe is concerned, the pipe vise should be equipped with lead or wood cheeks which will hold the pipe without scratching it.

The cutting tools should be sharp, and should be used only for brass pipe. It is bad practice to use the same tools on brass and iron interchangeably.

In some places it is required to cut a thread sufficiently long to leave one or more completed turns outside the connection, so that it is always possible to tighten it up in case of trouble. In other cases it is required that the thread be entirely concealed by the connection. The latter practice is to be recommended except in cases where there is inadequate superintendence or where the good faith of the workman is in question, because it is possible to cut too few threads on a pipe and when the joint is made up, there is no way of determining whether there are enough threads unless several turns are visible from the outside.

Cutting Pipe

Brass pipe is easy to cut with a metal saw and the saw cut leaves a clean edge. Pipe cutters roll the edge of the pipe inward and restrict its area. Therefore, the saw is preferable to the cutter unless the burr is reamed out after the cut is made.

Making Up Joints

Joints in brass pipe or in any pipe for that matter should be avoided wherever possible, especially is this true of joints which employ plain couplings.

Wherever it is necessary to make joints, the fit should be as perfect as possible.

In order to seal completely a connection between threaded parts,

some plumbers employ a mixture of red and white lead. Sometimes this lead mixture is put onto the pipe and sometimes it is put onto the coupling or female end of the connection. Putting the lead onto the pipe permits a thorough application and easy inspection, but has the disadvantage of forcing the excess to the outside where it mars the appearance of the pipe. The application of the lead mixture to the fitting, however, is not to be recommended. First, because it is apt to be less thorough, and secondly the excess material is forced inside where it hardens and restricts the area of the pipe.

It is preferable to make joints without any sealing material, such as lead or cement. One method which has been used with success on many important jobs employs a single strand of wicking, lubricated with tallow or a similar material. Such wicking is wound around the pipe three or more times, beginning one or two threads

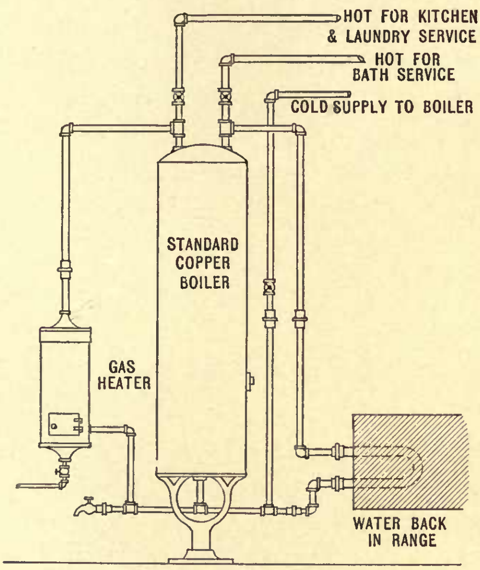


Figure 39. Connections for hot water boiler with gas and range waterback heaters. It will be noted that the water inlet is from the bottom of the boiler only. Where the inlet is carried in from the top cold water sprays from the anti-siphon hole into the hot water every time water is drawn from the boiler. In above arrangement the chilling effect of incoming water is entirely eliminated by connecting to the bottom, where it enters directly into the heater and into the boiler, depending upon where the demand exists.

It will also be noted that hot-water pipes from the heaters lead to the top of the boiler. It would be preferable to connect these pipes directly to the boiler; however such a boiler would be special. In any case the friction through the heater is so much greater than directly from the boiler that there is no danger of drawing cold water through the heater, when there is hot water in the boiler. By this method of connection hot water is available in the shortest possible time after heat has been applied. It also gives the most economical method of producing and storing hot water.

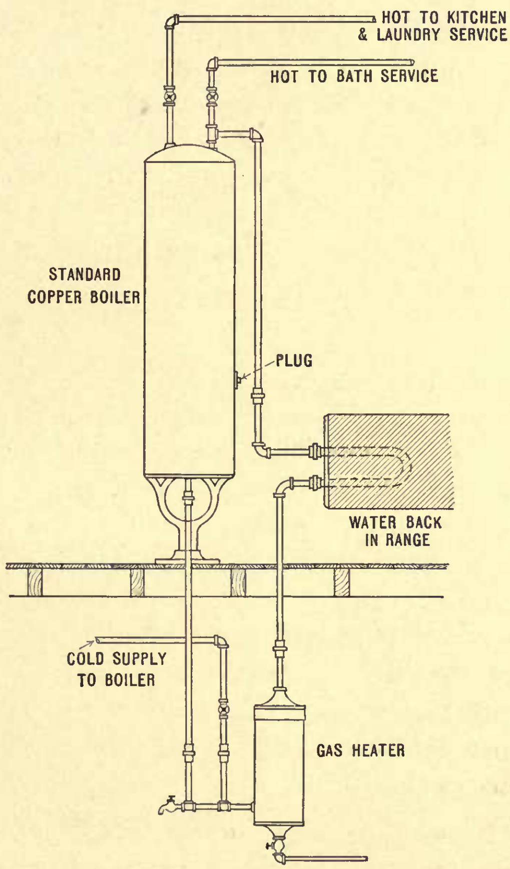


Figure 40. Here are shown methods of connecting a hot water boiler with two heating elements, one on the same floor with the boiler and the other on the floor below. The same arrangement of piping would apply if a waterback in the house-heating boiler were also connected with the same boiler. We would merely insert the waterback in series with the other two heaters.

The same principle obtains as set forth in Figure 39. Cold water enters the bottom and hot water at the top of the boiler. In this way hot water is obtained in minimum time and cold water is applied at the coldest point in the system so that it does not chill water that has already been heated.

Architects
Trowbridge &
Livingston

Engineer
F. Titus

from the end. A joint made in this way will remain tight indefinitely. Another method that is used in some of the best work is to tin the threads and solder the joint.

Bends Properly made brass pipe may be bent on the job to make elbows, expansion loops and for other special uses. The following method has been used successfully for a number of years. The pipe to be bent is warmed slightly and filled with sharp sand which also has been heated. It is then closed on both ends and may be bent, without further heating, in a pipe bending machine, or by hand around a suitable form. The sand will prevent the pipe from collapsing and keep the opening uniform throughout.

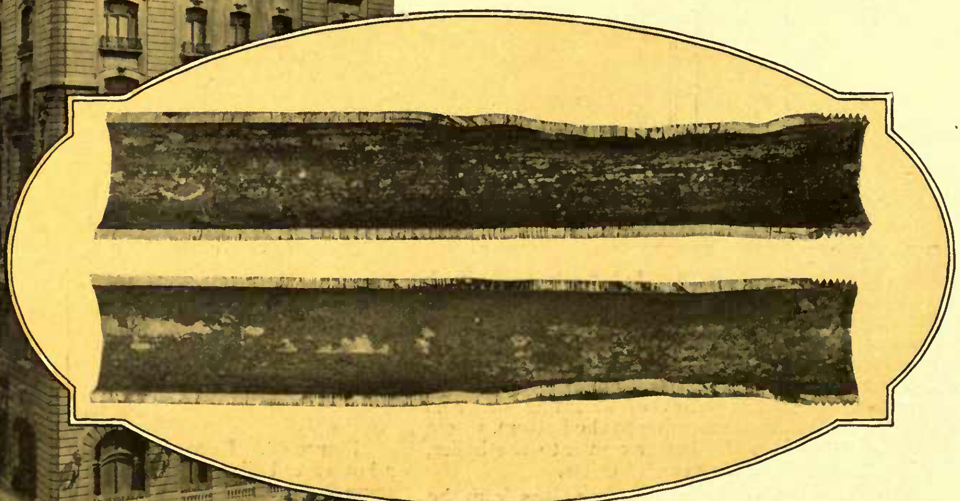


Figure 41. The St. Regis Hotel, New York, has perhaps the finest plumbing installation ever made in a public building. Bridgeport Plumrite Brass Pipe was used throughout for hot and cold water service. There has never been a leak in the system since the hotel opened in 1901. The piece of pipe here shown was taken out when an alteration was made in 1922. The surface has not been touched in any way. Examination will reveal full thickness of the wall, perfection of the threads and the softness of the pipe is evident from the crushing effect of the pipe tongs which were applied to it when it was removed. The rough appearance of the interior surface is due to a deposit and not to corrosion.

COST OF BRASS PIPE

America is just learning the lesson of economic building. Up to quite recently most building in this country was done on the principle of lowest first cost, or else it was done on the basis of "the best of everything" without regard to cost. Neither one of these systems is economically sound. The best of everything without regard to cost is sometimes extravagant, and any structure that is built on the basis of lowest first cost is bound to give a temporary service and result in extraordinarily high maintenance and repair cost.

The only economically sound principle for the choice of materials and methods in building construction is that of lowest ultimate cost, including maintenance, depreciation and repairs.

Theoretically the "One Horse Shay" was built along the proper lines because all its structural elements were chosen to give exactly the same amount of service. In practice, of course, we can never hope to attain the perfection of the famous "One Horse Shay." We can, however, avoid limiting the usefulness of the main structure by the installation of inferior details.

One of the common mistakes made in many high-class buildings is the use of perishable materials, such as iron and steel in the water service piping systems, where brass at a slight extra first cost would eliminate upkeep and damage due to leaks—to say nothing of the tremendous expense of renewal which is sure to take place whenever an iron or steel-pipe installation is made in a building, otherwise permanent in character.

Items of Cost

In designing a piping system for hot and cold water service on the basis of lowest ultimate cost or maximum return on investment, the following factors must be considered.

1. First cost of pipe and fittings.
2. Installation of pipe and fittings.
3. Depreciation and repairs.
4. Cost of renewals.

In addition to these four elements, consideration must be given to the possibility of damage to the building and its furnishings as the result of rusty water, leaks or complete failures.

First Cost

First cost of pipe and fittings is determined by cost of materials and the quantity required. The relative cost of iron and brass pipe varies with the market conditions.

As was explained on page 34 brass pipe, not suffering any loss of carrying capacity due to corrosion, can be used in smaller sizes than either iron or steel. If in figuring an installation, credit is given for the difference of size of pipe, a substantial saving in first cost will be accomplished. The best way to visualize the difference in first cost between various kinds of pipe is to figure an actual installation, because each installation will give a somewhat

Figure 42. The Sherry Hotel, one of the famous places in latter-day New York, was built in 1896 and equipped with Bridgeport Brass Pipe. In 1919 it was remodelled by Guaranty Trust Company into a commercial building which involved considerable alteration in the plumbing arrangements. The brass pipe removed in the course of these alterations was found to be in such perfect condition that it was actually re-installed in the new construction. The sample of pipe illustrated shows the perfect condition inside and outside. This sample is reproduced exactly as it came from the job after 23 years of service.

Architects, McKim, Mead & White. Engineer, Mortimer Foster of McKim, Mead & White.

Architects, Cross & Cross
Engineer, Clyde R. Place

different result depending upon the design and the character of the service required.

For purposes of illustration, a 14-story bank and office building designed for lower New York and costing approximately $850,000 has been chosen. The plumbing system is of the gravity type which employs house tanks and pumps. It comprises 142 toilets and corresponding number of other fixtures, and the piping represents a total investment of approximately $3,200, while the same system of piping equipped with brass pipe and making allowance for the superior carrying capacity of brass pipe by using a size smaller throughout will cost approximately $4,300.

The brass pipe in this case costs $1,100 or approximately 35 per cent. more than the galvanized iron or steel. The water service is the most important element in the successful operation of the building. To get a leak-proof permanent job for an expenditure of a little more than one-tenth of 1 per cent. of the cost of the building seems like an excellent investment.

Installation Cost

Theoretically there should be a difference in installation cost of iron, steel and brass in favor of the cheaper pipe. Brass pipe should cost a little more to install than iron or steel, because its superior quality and appearance should inspire better workmanship on the part of the plumber. Then too, knowing that the installation is put in for the life of the building, extraordinary care should be exercised to make perfect joints. The question of installation costs has been canvassed among various prominent plumbing contractors and not one was found who made any allowance for extra labor to install brass.

Depreciation and Repairs

Depreciation and repairs cannot be figured accurately. However, it is safe to say that if the water does not contain ammonia, nitrates, nitrites, etc., such as come from decaying vegetable matter, that properly installed brass pipe will never require repairs and will last as long as the building itself.

In 1901, Bridgeport Plumrite Brass Pipe was installed in the St. Regis Hotel, see Figure 41. Recently the installation was inspected and found in perfect order. Mr. Hahn, the President, gave the Bridgeport Brass Company a letter stating that not one cent had been spent in repairs, and that no leaks had developed during the 21 years which the pipe had been installed. Another example of the durability of brass pipe is evidenced by experience in the Sherry Hotel see Figure 42. Bridgeport Brass Pipe was installed in this hotel in 1896. In 1919 the hotel was remodeled into a commercial building for the Guaranty Trust Company. In the process of remodeling much of the piping was removed to conform with new layouts. The Bridgeport pipe was found to be in such excellent condition that it was re-installed in the new work. As far as could be determined, this pipe was in just as good condition as when first installed more than 23 years before.

As far as iron and steel are concerned, the deterioration varies considerably with the character of the water, the flow, the temperature and the pressure. Where very hot water is used in large quantities, such pipe has been known to fail in New York City in the short space of 3 years. Under more favorable conditions of use, hot water pipe will last 10 or 12 years, using the same water. Repairs on iron and steel pipes are apt to begin in less than 2 years.

In order to take some definite account of depreciation and repairs, figures should be assembled on the actual performance in the locality where the installation is to be made. Ordinarily from 7 to 10 years for galvanized steel pipe, and from 7 to 12 years for galvanized wrought iron pipe may be assumed as average. Figures have been given which allow shorter life and longer life than here set forth, but it is believed that these figures will be found extremely conservative and fair in ordinary cases. Where pipe will not last longer than 7 years, it certainly should not be used under any conditions, except for temporary work.

Some are installing deactivation plants with the idea of eliminating depreciation and repairs. Until such systems have been in use for 12 or more years, it will be impossible to tell how successful they are in practice. However, the upkeep of the plant itself after the first year will probably cost from $60 a year up for the smallest size plant and more for larger ones. In the meantime, the repairs and depreciation of the pipe system should be carried at some figure, even though it is considerably less than the ordinary figure until the exact benefits of deactivation have been proven in actual practice.

Renewal Cost

Renewing piping is an extremely expensive proposition, because in modern buildings it involves the tearing out of permanent construction work, as well as the disturbance of other pipes, conduits, etc. Ordinarily the tearing out and building in of a new piping system in a modern building will cost several times as much as the original installation, and as an installation it can never be as satisfactory as the original. An actual example is Goldman Sachs Building in New York. Galvanized iron pipe was removed from this building and replaced by Bridgeport Plumrite in 1922 at a cost of $12,000.

This hot and cold water piping system cost the building operators a great deal of money for repairs which finally culminated in its entire replacement. All this expense could have been avoided by using the proper pipe in the beginning. The actual difference in cost between wrought iron pipe and Bridgeport Plumrite Brass Pipe was only $647; a small price to pay for immunity from circulation and corrosion troubles.

The cost of rebuilding the piping system in this instance does not include damage done to the building, its furnishings and fixtures. After the installation was completed, it was necessary for masons, carpenters and decor-

ators to contribute toward repairing the damages incident to the work of renewal.

While it is desirable to take advantage of every factor that will reduce the first cost of an installation without impairing its usefulness, the fact remains that a brass pipe installation is worth in actual economic performance several times its cost over iron or steel.

Figure 43. Typical basin installation in Goldman-Sachs Building where Bridgeport Plumrite Brass Pipe replaced galvanized iron. The figures given in the text do not include the cost of reinstalling the walls, floors and ceilings of the building after the plumbing work was completed.

Figure 45. Cornell University Medical School

Architects, McKim, Mead & White
Engineer, Mortimer Foster of McKim, Mead & White

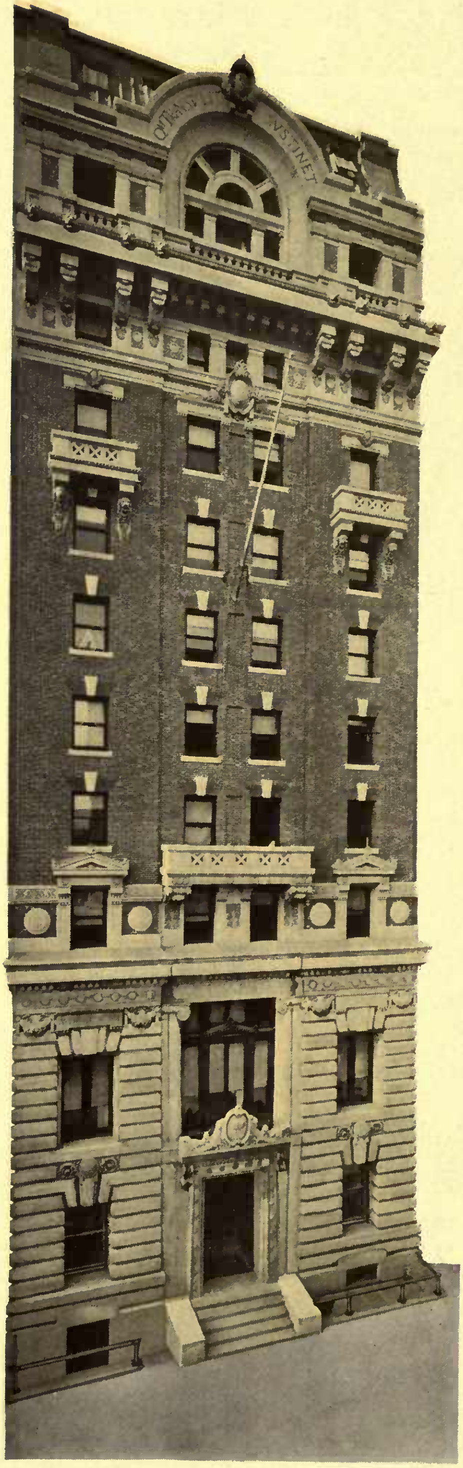


Figure 44. Old Yale Club, New York, now occupied by the Delta Kappa Epsilon Society

Architects, Tracy & Swartwout

Architects, Trowbridge & Livingstone

Architect, Charles A. Pratt

Figure 46. In the Knickerbocker Hotel, the principal distribution to hot and cold water risers was made above the ceiling of the main floor where a leak would have resulted in most serious damage. The danger of accident was eliminated by the proper installation of Bridgeport Plumrite Brass Pipe. When the Knickerbocker Hotel was converted into a commercial building, the brass pipe was found to be in perfect condition.

Figure 47, Speyer Building, New York.

Architects, De Lemas and Cordes
Engineer, A. R. Wolff